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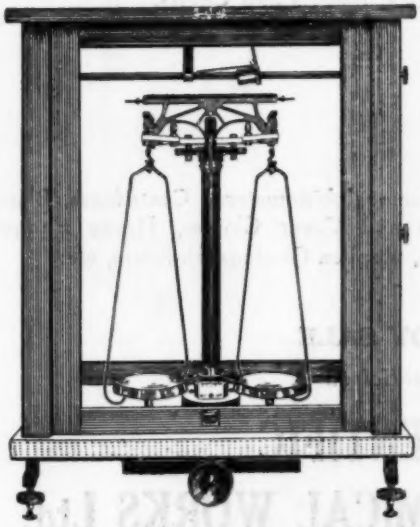

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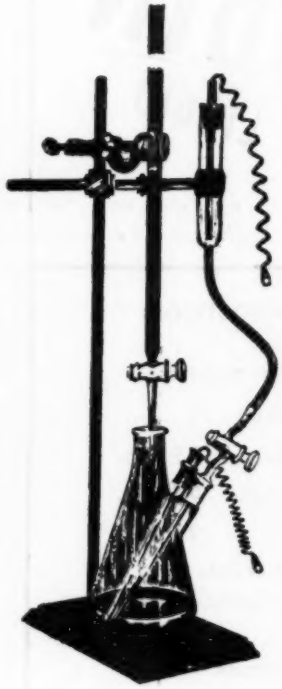

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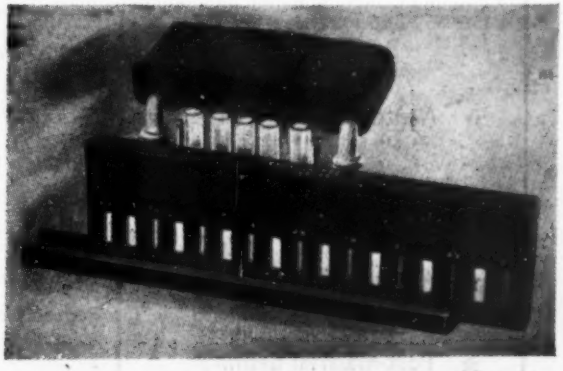

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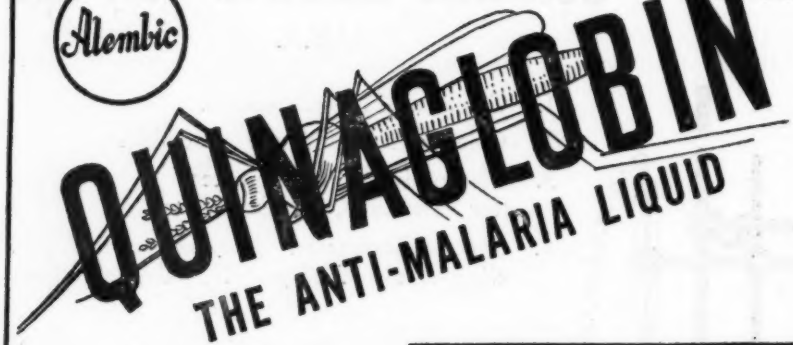

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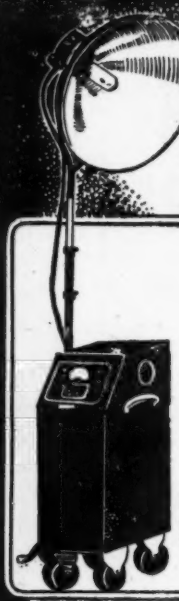

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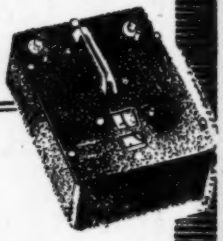

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SIR C. V. RAMAN AS PHYSICIST AND TEACHER*

A BRIEF review of the investigations in the field of crystal physics, carried out by Sir C. V. Raman and his pupils appears in this issue as a supplement.† We only wish to indicate here a few characteristic features of the scientific work of Sir C. V. Raman, his approach to research and his relationships with his pupils.

The most obvious characteristic is his great passion for physics coupled with an intense enthusiasm and volcanic energy. Even the most casual observer cannot fail to miss the fire in his sparkling eyes which seem to radiate this energy, and to be animated by the dynamic force of an active brain. He lives for his work as few men do, and by his exceptional tenacity of purpose and hard work in the pursuit of research he has set a shining example to others.

He has a deep insight into physical processes, and an intuitive sense of physical reality. He has often shown the ability to illuminate a whole subject with a few crucial ideas. His highest work shows the inevitable simplicity of all great work, and has been achieved by spontaneously taking the significant step at the right moment. He possesses in a remarkable degree the gift of seizing the vital point from apparently trivial observations. This genius for picking out the true significance of what to others would be an unimportant detail, and transforming it into a clue for the understanding of fundamental problems is brought out strikingly in his work leading to the discovery of the Raman effect itself.

Raman is a born experimental physicist, and has been guided by the conviction that

* From the Sir C. V. Raman Sixtieth Birthday Commemoration Volume *Proc. Ind. Acad. Sci.*, Nov. 1948, Bangalore.

† *Vide* Supplement.

real progress in physics can be achieved only by the application of considerations based on experience and reason to experimental observations of properly chosen phenomena. He has advanced directly and successfully along this straight path without often branching into mathematical physics. Yet whenever occasion arose he has shown that he possessed the mathematical equipment essential to the interpretation of his work. He has also recognised and acknowledged the fundamental importance of ideas of a mathematical or deductive nature. Thus, in the realm of his researches in crystal physics, he has realised the importance of group theory, and the theory of group representatations, and encouraged investigations based on such theoretical considerations. He has also shown facility in choosing the right type of mathematical technique needed in his work, and an uncanny faculty for seeing clearly through a mass of complicated mathematical calculations. His theory of the diffraction of light by high frequency sound waves is a striking example of this. Like all great physicists, however, he has placed facts first, and hypotheses always second.

Though the work of Raman and his school has lain in apparently diverse fields it is easy to discern a coherence and unity in them. The central and guiding theme of all his physical research has been optics in all its aspects. His special love has been for crystal physics, and in particular, physics of the diamond, in which subject he is a recognised authority. He has recently struck new paths in crystal physics, and introduced new concepts regarding crystal structure.

Another notable characteristic of Raman's scientific work is its sturdy individualism which is a consequence of the fact that when he started his career he belonged to no particular school of physics, but had to build one for himself. He is thus a true pioneer who has had the vision and courage successfully to explore unknown lands in physics. This circumstance has made him attach great importance to an independent approach to problems, and if his valuable example of striking out new and independent paths of research were to infect other scientific workers in our country, we are assured of a bright scientific future indeed. Further, the fact that he had to start work as an independent investigator without the facilities of an already well-equipped laboratory has brought out to the full his skill as an experimenter. Most of his experiments have required neither costly machinery nor any type of special techniques, but have been so simply devised as to be easily understood even by a layman. In fact, the apparatus with which he demonstrated the Raman effect is a model of simplicity and by no means a costly one, but nevertheless this simple experiment is one of the important milestones in the world's knowledge of nature.

It is perhaps not so well known that Raman has shown a fine æsthetic outlook in his research work. His choice of topics for investigation, and his way of handling them bring out clearly his innate artistic nature. His love of music, colour, light, vibration, symmetry, harmony, pattern, structure, and architecture is but the result of a deep appreciation of the beautiful in nature. His researches on musical instruments, numerous beautiful phenomena in wave optics, the colour of the sea, colour in the plumage of birds, iridiscent shells and mother-of-pearl, vibration in crystals, and above all his studies on the form, symmetry and structure of diamond based on fluorescence, phosphorescence and birefringence patterns are a but few examples of his æsthetic taste in research. He has one of the finest private scientific collections of diamonds and other beautiful crystals, and loves them as only a true artist can.

None who has come in contact with Raman can have failed to notice his very wide and catholic interest in many branches of science besides physics. He has perhaps done as much for chemistry as for physics. His interest in geology based on deep knowledge, especially in the fields of mineralogy and crystallography, has been a stimulant for the geological research of many workers in India. Some aspects of plant life, and animal life, specially birds, have always had a deep fascination for him. He has shown keen interest in and appreciation of astronomical and astrophysical research, both observational and theoretical. Indicative of his wide interests are his plans to build an astronomical observatory, a biological research unit and a mineralogical laboratory in the new Raman Research Institute. In spite of criticism from some quarters, it can be confidently claimed that by his collaboration and encouragement he has given the neces-

sary incentive to studies in mathematics even of the purest type. It is safe to say that there is no branch of science in which he has not encouraged creative and original work, and this augurs well for the development of fundamental research in the country in its new set-up.

Raman is not only a great investigator but also a great teacher in the true sense of the term. His ideas and personality have attracted many young research students, and he has held their loyalty and affection by extending a never-failing friendship to them. He has not only taught methods of physical research to his students, but by his own shining example made them realise the necessity for endurance, steadiness and hard work in the pursuit of knowledge. While giving help and encouragement in plenty, he has always expected and sometimes demanded from his students the best that they can give. The writer of this article has had many occasions to see the great care with which he would supervise the papers of his students, sometimes going to the extent of re-writing whole sections. No paper ever leaves his laboratory until he is completely satisfied with it.

The feelings of respect and admiration which his students have for him can be ascribed to his fairness and even generosity in acknowledging a pupil's ideas or originality. He is very liberal minded and gives away whole lines of research which lesser men would be tempted to keep for themselves. Whenever he discovers any originality in a pupil he will do all he can to develop it. His simplicity and informality are best seen in his discussions with students. Some penetrating remark made by him at such discussions has been the starting point, as some of his pupils have confessed, of a complete line of investigation undertaken by them later. This has been true not only in his own special field of research, but in other subjects as well.

Raman has rendered signal service to scientific advance in India as much by his contributions to knowledge as by his training of students in methods of research. He has exerted a profound influence on the work and outlook of not only his students but most of his contemporaries.

Unlike many scientific investigators who are giants in their own laboratories but dwarfs outside unable to take a due share in the national life of their country, Raman has fully participated in several walks of national activity, and is eager to serve the cause of scientific and technological advances in India. Possessing in a rare measure the extraordinary gift of making the most difficult problems in physics appear simple, and with a keen and irresistible sense of humour, he has admirably filled the role of an eminent popular lecturer on scientific subjects. Popularisation of science in the country owes not a little to his gifts of eloquence and exposition.

To have accomplished so much in one's own chosen field of research might have contented many men, but it is not enough for Raman. He has an unquenchable thirst for knowledge, and great energy for exploration, and for him "'Tis not too late to seek a newer world". On this occasion of his Sixtieth Birthday, we heartily wish him many more happy returns of the same with the hope that his vision and wisdom may well and truly serve the cause of science.

B. S. MADHAVA RAO.

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The ceremony was attended by diplomatic representatives and guests from participating countries, the press and Unesco officials.

INDIAN SOCIETY OF AGRICULTURAL STATISTICS

THE Second Annual General Meeting of the Society was held at New Delhi from the 23rd to the 25th of October, 1948. The meeting opened on the 23rd with a Presidential Address by Dr. Rajendra Prasad, President of the Society. Stressing the importance of correct and reliable statistics, Dr. Prasad said that accurate statistics formed the foundation of all our future planning. The work that the Society had undertakn was, therefore, of the highest national importance. He then referred to the progress already made in the methods of collection of agricultural statistics and said that the method of random sampling devised by statisticians for this purpose marked a great advance, and he was glad that the method was being extended to all the important crops in the country. Along with this question was also that of the cost of cultivation of crops which was equally important, and he urged statisticians to devote their attention to finding out the cost of production of the various crops and thus help the Government in their efforts to control and fix the prices of commodities. The work of the Society, he continued, would likewise be of value to the Government in their plan of giving aid to agriculturists in determining the extent of that aid and the method of distribution. Speaking of India's cattlewealth, Dr. Prasad said that the absence of accurate statistics was more pronounced in animal husbandry, especially because of the difficulties peculiar to that field. Yet, even there, one should not under-rate the need of having accurate information not merely of the number of cattle in the country, but of their individual worth. He then referred to the World Agricultural Census to be held in 1950, in which India had agreed to participate, and asked the statisticians to consider whether it could be carried out jointly with the population census without loss of efficiency.

Earlier, Dr. P. V. Sukhatme, Secretary of the Society, in his report of the year's activities, said that in the publication of a scientific journal, which was one of the Society's principal activities, they had to meet with great difficilties first for lack of funds and secondly for want of a suitable printing press equipped with mathematical and statistical types. He was, however, happy to place before the meeting a specimen copy of the first number of the Journal which had just been received from the press. A special feature of the Journal was the Hindi supplement giving summaries of the articles published in English. The Society had also prepared a glossary of Hindi equivalents of all principal terms in statistical science.

On the 24th October a symposium on the 1950 World Agricultural Census was held under the chairmanship of the Hon'ble Shri Jairamdas Doulatram, Minister for Agriculture, Government of India. The meeting was well attended by a number of statisticians and those interested in Agriculture from the Centre and the provinces. Emphasising the importance of the role of statistics in the formulation of economic planning, the Hon'ble Minister urged statisticians to devise ways and means of collecting statistics which were true, accurate and dependable; for, "no progress is possible in any field unless we are able to see the path we are treading or the goal we have to reach, and reliable statistics is the lamp that lights our path". Stressing the need of having a reliable census, he exhorted statisticians to produce statistics which for their accuracy and dependability could not be challenged and which will put India on a par with other countries in this field. He suggested that for this purpose the non-official element in the country should be mobilised to co-operate with and help the government in its task. This would help to remove suspicion and hesitation from the minds of the public and prepare the way for accurate results quite in contrast with the censuses of previous years which had been undertaken largely in an atmosphere of distrust and suspicion of the ruling class. In conclusion he suggested that a 'rehearsal census' should be held in 1950 as a preliminary to the census in 1951.

The main speakers included Messrs. W. R. Natu, Economic and Statistical Adviser, Ministry of Agriculture, Govt. of India, M. W. M. Yeatts, Census Commissioner, Govt. of India, Sir Shri Ram, Patron of the Society, Prof. J. N. Warner of the Allahabad Agricultural Institute, G. M. Sankpal, Director, Bureau of Economics and Statistics, Govt. of Bombay, Dr. N. S. R. Sastry, Reserve Bank of India, Bombay, and Dr. P. V. Sukhatme, Secretary of the Society.

Following the symposium a number of technical papers bearing on topics of interest to agricultural statisticians were read. Prof. K. B. Madhava was in the chair. The reading of papers was continued on the afternoon of the 25th of October with Mr. R. S. Koshal in the chair. The session concluded with a public lecture on the 'standardisation of agricultural products' by Dr. T. G. Shirname, Agricultural Marketing Adviser to the Government of India.

Among the messages of greetings received on the occasion of the Second Annual Meeting were those from Sir C. V. Raman, the noted Indian scientist, and the Hon'ble Shri. N. V. Gadgil, Minister for Works, Mines and Power, Government of India. Sir Raman in his message said:

"The enormous importance of the subjects falling within the purview of the Society can scarcely be questioned. The problems with which the Society is concerned are so essentially linked with agricultural practice and administration and their improvement that they cannot be divorced from these and regarded merely as a field for the application of the mathematical theory of Statistics. I find myself therefore in the heartiest sympathy with the points of view which the Society and its activities represent, and which you have so ably

advocated in the past. I am writing to send my cordial greetings to your President and members and my good wishes for the success of the meeting."

Sir Pheroze Kharegat was elected by the Society as its Honorary member as a mark of its appreciation of his services in the cause of Indian agriculture. Prof. N. G. Ranga was elected as an additional Vice-President of the Society during the year.

INTERNATIONAL CONGRESS OF APPLIED MECHANICS

THE SEVENTH INTERNATIONAL CONGRESS OF APPLIED MECHANICS was held at the Imperial College, London, from the 5th of September to the 11th of September 1948 under the Presidentship of Sir Richard Southwell. About 800 delegates from all parts of the world attended it, and these included distinguished workers like Th. Von Karman, Sir Geoffery Taylor, Prof. S. Timoshanko, Prof. H. L. Dryden, Prof. W. Prager.

On the 5th of September the Governing Body of the Imperial College invited the delegates to an evening party. From the 6th to the 11th of September there were on each day two technical sessions and at least three general lectures. The Congress was divided into four sections in the following manner :—

Section I. Elasticity and Plasticity.
Section II. Aerodynamics, Hydrodynamics and Meteorology.
Section III. Thermodynamics, Heat Transfer, etc.
Section IV. Vibrations, Lubrication, Electronics, etc.

About 200 papers were accepted to be read in the four sections. Dr. B. R. Seth was the only Indian to read a paper. Sections I and II had each a sub-section. On the average about three papers were read and discussed in each session of about three hours. This is a very good practice and should be adopted by the Indian Science Congress Association and other scientific bodies. They should not accept all papers as a matter of course. A fairly comprehensive summary of all accepted papers was available before the session began, and in some cases even complete papers were given to the delegates.

In the first technical session of the Congress on the 6th of September the discussion on "Finite Elastic Deformation" was opened by Prof. L. M. Milne-Thompson of the Royal Naval College, Greenwich. He explained how the subject initiated by Dr. B. R. Seth in his paper published in the *Transactions of the Royal Society*, and developed by Prof. F. D. Murnaghan, could be extended to aelotropic bodies. Dr. B. R. Seth, commenting on the paper, gave practical examples where the theory as applied to aelotropic bodies, had been successfully worked out by him in a series of papers. Mr. R. S. Rivlin carried the discussion further. Prof. H. Bradenburger enquired whether the theory could be applied to explain why a member under tension did not behave in the same manner as when it was put under compression. Dr. Seth's work showed that it could be applied. Dr. H. K. Swainger gave his results for "severe deformation". Prof. A. Sigorini also gave some of his results.

Dr. B. R. Seth read a paper on "Bending of cylindrical shells with vertical walls". One of his results that the solution for the bending of a supported rectiliner plate under uniform pressure could be made to depend on the corresponding torsion solution was much appreciated by Prof. Milne-Thompson, Sir Geoffery Taylor and others.

It is difficult to give an account of all the papers that were read in the various sections. One can therefore mention a few of the important ones. Sir Geoffrey Taylor gave a paper on "Swirl Atomisers" and showed where the Engineers had gone wrong in the calculation of the boundary layer Th. Von Karman and Prof. C. C. Lin spoke on the theory of the turbulence and Prof. H. L. Dryden on the design of wind-tunnels.

Of the General Lectures delivered at the Congress one must mention the following :—

1. Recent developments in the Mathematical theory of plasticity by W. Prager.
2. Cinema aid in teaching mechanics, by L. Couffignal.

The technique adopted in the second was very good. It was a sound film on the kinematics of the universal milling machine.

On the social side there was a reception at the Senate House by the Vice-Chancellor of the University of London, an informal dance, reception by the Lord Mayor at the Guildhall and the Congress Banquet. The Indian Students' Hostel at Bayswater gave a dinner in honour of Dr. B. R. Seth. He gave them a talk on "Harnessing of Scientific Personnel in India".

A number of excursions were arranged for the delegates from the 13th to the 16th of September. Delegates visited the National Physical Laboratory, College of Aeronautics, National Gas Turbine, Royal Air-Craft Establishment and General Electric Co.

The Editor of the *Applied Mechanics Reviews* invited Dr. B. R. Seth to become a corresponding reviewer.

WINTER RAIN IN THE UNITED PROVINCES

S. L. MALURKAR

(Colaba Observatory, Bombay)

IT is well known that the winter rain over North India is due to the passage of complex low pressure areas (called as western disturbances in India) under the influence of extratropical depressions.[1] These complex low pressure areas can be divided or broken up into a number of distinctly evolving simple low pressure areas each of which move almost ENE.[2]

While travelling between Delhi and Allahabad, it was noticed that *sometimes* the weather west of a place between Fatehpur and Cawnpore was dry and almost clear while to the east of the same place, the sky was mostly clouded and was occasionally threatening. Even the past weather of the places to the west of Cawnpore would have been dry. The secondary low pressure area which gave weather to the places east of Cawnpore got the moisture feed from more easterly longitudes.

The pre-monsoon period can also be included under the category of winter here.

The moisture-bearing winds are those that flow at or below 2 km. While the air at higher levels gives a dry feed and is responsible for instability weather. The more equatorward secondary low pressure area of a western disturbance affects only the lower heights[3] of the atmosphere which happen to be the moisture-bearing areas, the orography of the central parts of the country should be expected to exercise a directive influence on the weather. It is accepted generally that the effect of the mountains disappears at the height corresponding to two or three times the elevation of the mountain. With an orographic map, it should be possible to draw a sort of free stream lines to determine how the orography affects the weather. With an orographic map of India (0·5 and 1·0 km. contours) some free line curves were drawn (Fig. 1).

FIG. 1

The observations printed in the "Indian Daily Weather Report of the India Meteorological Department" and in the Provincial Raingauge Reports in the "Gazette of the United Provinces" were used to study in detail over a wide area and over a period of three to four days *prior* to the development of weather in the U.P. The rainfall recorded at the provincial raingauge stations were plotted against stations tabulated in the groups arranged SW to NE and could illustrate well the movement and evolution of the secondary low pressure areas.

Two typical instances were specially studied. In one, for 27th December 1945, Allahabad recorded one inch of rain. Stations in east U.P. had well distributed rain. In the west U.P., the rainfall was scanty or absent even on previous days. The sky at Delhi gave no indication of weather in the period.

In the second case, for 8th April 1946, fairly wide-spread dust or thunderstorms occurred in the east U.P. An airways pilot who flew from Gorakhpur to Lucknow on 8th afternoon saw a line squall following him. The mail plane pilot who left Allahabad to Delhi that evening said that he diverted to the south of Cawnpore and that he saw a line squall to the east of him.

25th December 1945.—0800 hrs. A low pressure area was over west Rajputana and Sind. There was hardly any clouding in the tract of the country covered by the stations Dwaraka, Bhuj, Deesa, Agra and Bareilly or in the tract covered by Jalagaon, Khandwa, Hoshangabad, Jubbulpore, Saugor (C.P.), Sutna and Allahabad.

The upper winds at 1·0 km. in the central parts of the Peninsula had changed since the previous evening. A 'natural' upper air stream line could be drawn from Madras to Bangalore and then northwards upto Ambala, so that a southerly flow which could ultimately be partly traced to the Bay of Bengal was possible. In N.W. India, a low pressure area was indicated in the upper air. The upper air along the west coast of India was determined by a high pressure area over the east Arabian Sea. A corridor of low pressure existed in the upper air at lower levels from south-west Peninsula to south Rajputana. The N.E. monsoon winds were moderate to strong in the southwest Bay of Bengal. The pressure change in the previous 24 hrs. and the pressure departure from normal were negative over northwest India but were not so over the United Provinces. It had rained 1½″ at Colombo and less than ten cents at Trincomalee and Hambantota in the previous 24 hrs.

1700 hrs. The northward upper air stream line that could be traced to the Bay of Bengal had shifted northwards: Masulipatam—Hyderabad and then northwards (due to the afternoon low?). The N.E. monsoon had slightly strengthened and gripped the winds at Madras and Bangalore. The area of negative pressure change and negative pressure departure had slightly moved over to the United Provinces. Otherwise, the conditions were the same as in the morning.

26th December 1945.—0800 hrs. Traces of low clouding could be observed west of Hoshangabad and Saugor (C.P.). The area of

negative pressure change was extending from the east United Provinces to Assam and it was positive in northwest India. The lowest pressure departure was in north Central Provinces, near Saugor and Jubbulpore. Less than ten cents of rain had fallen at Nowgong, Sutna, Allahabad, Benares and Alleppy. It was still raining at Allahabad and Benares. Allahabad had an easterly and Benares had a northwesterly wind (force 2).

In the upper air at 1·0 km., the northward stream line which could be traced to the Bay of Bengal was again Madras-Bangalore-Hyderabad and then northwards. The upper winds at Bombay, Nagpur and Jubbulpore were SSW and strong at 1·5 and 2·0 km. and gradually veered to west at higher levels. Bhopal had also strong SSW upper winds. A low pressure area in upper air (at 1·0 to 1·5 km.) was over northwest Central Provinces and east Central India.

From the *Provincial Raingauge Reports*: Mau in Jhansi; Rath; Madha and Khajwa in Hamirpur; Banda, Girwan and Baberu in Banda districts; and Fatehpur and Lucknow recorded light rain to the west of Allahabad. There was no rain at the more westerly stations recorded either on 26th or on preceding days.

1700 hrs. Allahabad had a thunderstorm. The belt of negative pressure change had moved further east.

27th December 1945.—0800 hrs. Pressure change in the previous 24 hrs. was positive all over the country, outside Chotanagpur. Orissa and parts of Bengal and Assam. Pressure departure was positive over the central parts of the country.

At 1 km. the upper air stream line which could be traced to the Bay of Bengal was Masulipatam—Sambalpur—Gaya and Gorakhpur. An upper air low could be seen over the east United Provinces and West Bihar. Past weather: Lucknow had less than ten cents rain. Bahraich ½", Sutna ½", Allahabad 1", Gorakhpur ½", Benares ½" and Gaya ½".

From the *Provincial Raingauge Reports*, arranged according to districts lying in groups southwest to north east:

One station out of four recorded very light rain in Sitapur, 3 out of 9 stations had rain in Banda, 1 out of 4 in Gonda and 2 out of 3 in Bahraich districts, 1 out of 3 in Fatehpur, 1 out of 4 in Rae Bareli, 1 out of 6 in Fyzabad and 2 out of 3 in Pertabgarh districts; 8 stations out of 8 in Allahabad, 5 out of 5 in Jaunpore, 6 out of 6 in Basti, 5 out of 6 in Azamgarh and 5 out of 8 in Gorakhpur districts; 1 station out of 5 in Mirzapur, 2 out of 3 in Benares, 3 out of 4 in Ghazipur and Ballia districts recorded rain.

7th April 1946.—0800 hrs. A low pressure area was over west Rajputana and Sind East of Long. 77° E and north of Lat. 13° N, even the surface winds had a southerly component. It was raining over Assam and north Bengal. It had rained in the western Himalayas and in the S.W. Peninsula. Minimum temperatures were below normal in the southeast United Provinces.

In the upper air at 2·0 km., a low pressure area could be detected extending from the northeast Punjab to east Central India and the northeast Central Provinces.

From the *Provincial Raingauge Reports*, it is seen that Pharendra in Gorakhpur and Deoria in Deoria (formerly part of Gorakhpur Dist.) districts had each 2"·92 rain. On the 6th, fairly widespread rain had been recorded in Ballia, Deoria, Gorakhpur and Basti districts.

1700 hrs. Skies were clear at Benares and Allahabad. They were partly clouded at Guna, Saugor (C.P.), Jubbulpore, Sutna and over Chota Nagpur. At 1·0 km. in the upper air, there was a low over east Central India and adjoining districts of the United Provinces. At higher levels the westerlies were running over the whole of the United Provinces.

8th April 1946.—0800 hrs. The low pressure area on the surface chart extended from north Rajputana to the southwest United Provinces. Surface winds continued to show southerly east of Long. 78° E. Skies were partly clouded at Allahabad, Sutna and Nowgong. Delhi was overcast and it had rained in the past hour. It was still raining in Assam and north Bengal. Over the rest of Bengal, skies were partly to mostly clouded. Near the United Provinces, among the departmental observatories, only Nowgong reported rain. Minimum temperatures had risen in the east United Provinces.

Upper air flight at 0900 hrs. at Allahabad gave easterly to east-southeasterly upto 1·5 km. Bareilly was strong east to southeast upto 1·5 km. An upper air low, extending upto a height of 1·5 km. above sea level, was over the United Provinces, the southeast Punjab and north Rajputana.

From the *Provincial Raingauge Reports.* Three out of six stations in Cawnpore district had rain (each more than 0"·38), 1 out of 4 had very light rain in Mirzapur district. No other station in the plains of the U.P. recorded any rain.

1700 hrs.—A low pressure area was over the north Central Provinces and east Central India caused partly by the afternoon heating. A high pressure area was enclosing Daltonganj and Hazaribagh which were having thunderstorms at time. Allahabad reported thunder. Cawnpore and Mainpuri had recorded dust or thunderstorms. Agra had a drizzle.

According to newspapers, thundersqualls and dust storms occurred over a wide area from Fatehpur to Benares.

The thick clouding approached Allahabad from west-north-west. It broke out with a severe duststorm at Allahabad at about seven O' clock in the evening and was over Bamrauli about 20 minutes earlier.

9th April 1946. From the *Provincial Raingauge Reports*, it is seen that rain was recorded in 3 out of 4 stations in Ballia, 4 out of 4 in Ghazipur, 3 out of 3 in Benares, 2 out of 4 in Gorakhpur, 3 out of 5 in Deoria, 3 out of 6 in Azamgarh, 2 out of 4 in Jaunpore, 4 out of 5 in Mirzapur, nil in Allahabad, 1 out of 5 in Basti, 1 out of 6 in Fyzabad, 2 out of 3 in Fatehpur, one out of 4 in Sultanpur, 1 out of 8 in Hamirpur, 4 out of 9 in Banda and 1 out of 4 in Jalaun districts.

The main lines of argument and conclusions, are given here.

In the first example 27th December 1945, most of the rain fell to the east of the line drawn from Fatehpur to Basti or Gorakhpur. The pressure changes on the weather chart show the eastward passage of a low pressure area which was over Sind and W. Rajputana on 26th and its secondaries. These produced little precipitation in the plains until they had a S-ly feed from regions east of Long. 77° E. In the northern hemisphere a northward moving air stream has latitudinal convergence and tends to become less stable in its mass. If other conditions are suitable, weather is produced. An air stream with a good sea travel, after only a small northward displacement in a given amount of time may cause clouding and even precipitation. Stream lines on 25th and 26th had a run from Madras to Bangalore and then northwards but were not moist enough to give rain in the Central Provinces. The N.E. monsoon was moderate to strong in S.W. Bay of Bengal and an infeed of N.E. Trades occurred into the above stream lines; activating some particular secondary low.[4] The S-ly feed was not deep and above 2 km. the winds were W-ly. These higher level winds could be associated with the rear of a low of a western disturbance at a higher latitude and would be bringing in fresh cold air at higher levels. In fact, *the strengthening of the westerlies at higher levels can be taken to usher in colder days in winter over N.W. India and in the U.P.*

Fresh incursion of air at higher levels, colder than what existed there previously would decrease the stability in the air along the vertical. The fresh incursion of the S-ly air at lower levels bringing in more moist and warmer air than what existed previously has also a similar effect on stability. Along with latitudinal convergence, the air, now at the locality, can well maintain convection, if once started.[5] The causes of initial vertical movement in the production of thunderstorms are one or more of: (*a*) the 'cold front' of these secondary low pressure areas. It is well known that after the thunderstorms in winter the wind shifts to a W-ly or N.W-ly direction from its previous E. or SE. Each secondary has its own wind shift and it is only after the wind shift occurs that drier and cooler days set in. (b) Orography. (c) Wind velocity gradient which express the same condition in more general terms. (*d*) The unequal heating or insolation or (*e*) the long period oscillations of the isopycnic surfaces.[5]

In April 1946—usually a dry season in the plains of the U.P.—the plains of the west U.P. had little rain. The moist feed came from longitudes further east than on December 26th 1945. The secondary low pressure area was only detectable below 2 km. It was raining in Assam and N. Bengal and thunderstorms had occurred in S. Bihar and Chota Nagpur. Stream lines at lower levels passing over these regions would be moist. At higher levels, the rear of more northerly low pressure area of a western disturbance was exercising its influence, i.e., it was bringing in fresh cold air at higher levels. Hence the vertical structure of air was favourable to maintain convection. The causes of initial convection are the same as before except that insolation plays a greater part as summer is approaching. When the secondary low pressure area (with a small vertical extent and which was responsible for bringing into juxta-position of different air streams) passed ENE wards; the weather in the east U.P. cleared up till the next cycle of secondaries appeared.

Fig. 2 represent diagrammatically the vertical structure of air mass before dust or thunderstorms.

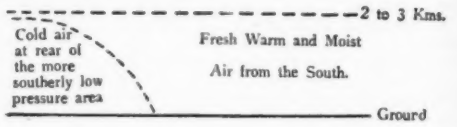

FIG. 2

(Thunderstorm in the U. P. in winter)

Fresh Cold Air at the rear of a Northern Low Pressure Area of a Western Disturbance

If at higher levels, cold air does not establish itself as shown by strong W-ly winds, the weather does not clear up completely and heat thunderstorms result.[6]

With an extensive chart, it is possible to watch the successive secondary low pressure areas. When the weather chart is limited, some working criteria had to be evolved based on the above and Fig. 1.

If a western disturbance was passing over 30° N, rain or clouding in the tract east of the Aravallis and west of the Vindhyas (represented by the observatories Dohad, Brijnagar and Jhansi) would show that a secondary low had a moisture feed and in its east-northeastward passage, it would be a pre-indication of weather in the west U.P. and neighbourhood.

Rain or clouding in the tract represented by the observations from Indore, Khandawa, Hoshangabad, Saugor, Jubbulpore and Sutna show that the secondary low further south than in the previous instance has had a moisture feed. This secondary, during its course of movement ENE wards would give weather in the east U.P. and neighbourhood.

The orography must also be kept in view.

If the secondary low pressure area has more closed isobars than usual, due to the anticlockwise motion of the winds round it, the moist stream would extend to more westerly longitudes and give weather there than if the low was weak.

For the east U.P., a southerly feed would come from longitudes east of Long. 78° E or 80° East. The upper winds of Bangalore, Hyderabad (Deccan) and Nagpur become significant. At lower levels, the upper winds from the more southerly stations must show a *SE component*, while those from higher latitudes must a *SW component*. In early summer, the seasonal low gets to be more marked. Then the *SE-ly components of winds on the east coast stations become significant*, i.e., at stations like Madras, Masulipatam, Vizagapatam, etc.). Sometimes, if Assam and Bengal be raining and a shallow low pressure area is found over east Central India, the belt

of thundershowers would extend from NE India even into the U.P. and these would be more marked in the eastern districts.

A weather forecaster is very much interested in the time sequence between the starting of SE-ly components in upper winds at places east of Long. 78° E. and along N. Madras coast and the subsequent weather in the east U.P. I have been unable to collect statistics. The changing of the wind directions to SE-ly on the east coast of India, the weather in the east U.P. and Chota Nagpur may be contemporary happenings of the weather pattern. It may not be logical to count the time interval *after* the setting in of the SE-lies. The pressure departure chart may be a better indicator. When a wave of a negative pressure departure passes eastwards across the country, this may be taken as an indicator of the passage of the low pressure area of the western disturbance. This low would some times induce the SE lies. However, an interval of 24 to 36 hours can be assumed to be the approximate time between the starting of SE-ly upper winds at lower levels east of Long. 78° E. and weather in the east U.P.

A comparison of the periphery of the rain belt with the free line curves drawn in Fig. 1 is quite close. Such instances can be easily multiplied. It is hard to determine theoretically the fanning out of the moist stream by orography of the central parts of the country. It should be possible, however, to carry out a model experiment in a tank or in a wind tunnel.

Squalls near Jubbulpore. Jubbulpore is situated at the crossing of two valleys formed by 0·5 km. contours (SW to NE and nearly SE to NW). The moist feed is directed along either of the valleys to the south of the place. When a 'cold front' of a low pressure area of a western disturbance passes to the north it brings in westerly or northwesterly winds. Owing to a sort of funnel effect of the valleys, more moist and more cold air are put into juxta-position and produce thunderstorms of more than usual intensity in the neighbourhood. The squalls produced in the pre-monsoon months at Jubbulpore are more severe than in many places in the Central Province; and tornadoes also occur occasionally (*vide* May 1936).

1, 2 and 3. Malurkar, "Forecasting Weather In and Near India," 1945, Bangalore, p. 102; Malurkar, Technical Note No. 1, p. 3. *Ind. Met. Dept.*; *Curr. Sci.*, 1947, **16**, 139, and 1948, **17**, 112, and under 1 see also Mal and Desai, *Technical Note No.* 25, *Ind. Met. Dept.*, 1947. 4. Malurkar, *Curr. Sci.*, 1947, **16**, 139. 5. —, *Proc. Ind. Acad. Sci.* (*Bangalore*), Sec. A 1943, **18**, 20, and **23**. 6. —, "Forecasting weather etc." *loc. cit.*, p. 112.

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UNIVERSITY INTERCHANGE BETWEEN U. K. AND INDIA

TO facilitate interchange between the universities of the United Kingdom and those of India, Britain is arranging for a number of travel grants.

The awards will be made on the recommendation of a Committee composed of representatives of the Association of Universities of the British Commonwealth, of the Committee of Vice-Chancellors and Principals of the U.K., and of the Universities Advisory Committee of the British Council.

Recipients will fall under three categories: distinguished scholars and scientists invited by universities for visits of at least 6 weeks' duration to enable them to meet fellow specialists and to mix with rising young workers in their own fields; university teachers on recognised study leave; and post-graduate research workers holding research grants. The latter two categories must undertake to spend at least 6 months of the academic session at the university where they propose to work.

Conditions for eligibility for university teachers and post-graduate research workers include suitable academic qualifications and experience, and a definite programme of work. The university named by the applicant as his proposed place of study must also be willing to receive him.

Applications

Applications are to be sponsored by the applicant's own university, and, in the case of university teachers, backed by the necessary finances—not less than 6 months' leave of absence on full pay. Post-graduate research workers are required to maintain themselves fully, while distinguished visiting scholars and scientists receive the necessary hospitality and costs of travel within the country from the inviting universities.

Grants are equivalent to the average cost of a return sea passage. For scholars and scientists invited by universities, passage may be arranged by air, depending on circumstances. Grants are normally paid in the U.K. in sterling, but in cases of necessity special arrangements may be made to pay part of the grant before sailing.

Particulars of visits which it is desired to arrange for distinguished scholars and scientists are to be sent by the inviting university to the Secretary, Committee for Commonwealth University Interchange, c/o The British Council, 3, Hanover Street, London, W.1. Persons in the other two categories are to send three copies of their application to the Vice-Chancellor or Principal of their own university for forwarding. January 31, 1949, has been fixed as the last date for the guaranteed consideration of applications, and the announcement of awards is expected to be about the end of March.

The most important thing is that this scheme provides for two-way traffic: facilities are provided both for Indians to visit the United Kingdom and for British scholars to undertake research and meet their colleagues in India.

SOME REACTIONS OF *p*-CYMENE

JAMES VERGHESE

P-CYMENE, 1-methyl-4-isopropyl benzene, is a common constituent of many essential oils. Sulfite turpentine is particularly rich in this hydrocarbon. Several methods mostly covered by patents are also available for its cheap production from readily available terpenes by vapour and liquid phase dehydrogenation.*

As a substituted benzene, *p*-Cymene is amenable to varieties of chemical transformations. thus constituting a potential raw material for the chemical industry. It is with this view, many of its more important oxidation, resinforming hydration and thermal fission reactions are now discussed.

(A) Oxidation Reactions

(i) *Electrolytic Oxidation:* Fitcher and Meyer[1] showed the intricate course of this reaction, having isolated 4-isopropyl benzaldehyde, 4-aceto-benzoic acid and terephthalic acid in one set, and 4-isopropyl-benzyl alcohol, 4-isopropyl- and 4-propenyl-benzoic acids, and probably diisopropyl-benzyl ether, in a second set of experiments.

(ii) *Vapour Phase Oxidation:* Senseman and Stubbs[2] isolated mostly 4-toluic acid (max. yield, 16·9% at 375° with sp. velocity 300 and 3-6 times the amount of air), besides terephthalic and formic acids, formaldehyde, carbon dioxide and water, using vanadium pentoxide deposited on porcelain as a catalyst. It appears >CH- group of the side chain is most readily attacked by this means.

(iii) *Liquid Phase Oxidation:* According to Stephens,[3,4] oxygen attacks the isopropyl group of the hydrocarbon. in the absence of any catalyst at 80°-100°, resulting in the loss of one methyl group as formic acid or carbon dioxide and water, with the formation of 4-tolylmethyl ketone. Oxidation of 1-methyl group also leads to 4-isopropyl benzaldehyde and benzoic acid.[4] However, in presence of finely divided manganese dioxide or manganese 4-toluate,[5] at 140°-160°, 4-toluic, terephthalic and formic acids, formaldehyde, 4-tolylmethyl ketone, carbon dioxide and water are produced. Oxides of chromium, cobalt, iron, nickel and copper act as promoters. The non-formation of alcoholic products in this reaction is rather striking. On the other hand, Palmer and Bibb[6,7] point out that oxidation in presence of a catalyst like a mixture of manganese and lead acetates, at 30°-50°, 40% conversion to 4-isopropyl benzoic acid[6,8] is obtained. This is by far the best method for the production of this acid.

According to Tunghna Kuan,[9] 4-tolylmethyl ketone (I) is obtained in 51% yield on oxidation with nitric acid (2 mols; d=1·12), but Hintikka[10] who used 4 parts of nitric acid (d=1·41) and 5 parts of water, could isolate only 10% of this ketone (I) besides 67·5% 4-toluic acid, 5% terephthalic acid and 16·5% nitro-compounds. It may be noted that styrenes like 4-methyl, and 4-α-dimethyl styrenes could be readily obtained from (I) by appropriate chemical reactions,[10] *via* the carbinols, but from a practical operative standpoint it would be economical to produce these styrenes and the carbinols directly from *p*-Cymene (see under Thermal fission) In this connection the experiments of Palmer and Bibb[6] are of interest. If oxidation by air is carried out at low temperatures below 50°, in presence of manganese and lead acetates, hydroxides or salts of a heavy metal of an organic acid as catalyst, αα-dimethyl-4-tolyl carbinol and 4-tolylmethyl ketone (I) are formed[8] which can be recovered after dehydration as the styrene and the ketone (I) by fractionation. All these products are of commercial significance. The ketone (I) is a good soap perfume and the styrene (4-α-dimethyl styrene) possesses analogous polymerising properties as the ordinary styrene, in yielding tough, colorless resins.[6] The carbinol which has a higher boiling point than α-terpineol, possesses good wetting properties suggesting its substitution for pine oil when higher alcohol content is desired. The styrene itself can readily be obtained by dehydration in presence of active carbon or graphite,[11] and this forms polymers and co-polymers,[12,13] by heat, cold con. sulpuric acid and benzoyl peroxide.

(B) Resin Formation, Hydration and Thermal Fission

(i) *Resin-forming Reactions:* Useful resins could also be obtained directly by chlorination of *p*-Cymene at temperatures above 100° in presence of Al, Fe or Zn, the cymyl chloride formed *in situ* undergoing a self Friedel-Crafts reaction, resulting in the formation of a dimer. The resins thus obtained however generally contain 10-30% chlorine (probably by nuclear chlorination and other causes).[14]

Varieties of resins can be obtained by previously incorporating other ingredients with *p*-Cymene. Addition of *o*-dichloro benzene gives a resin of higher chlorine content with added resistance to weather and water compositions. Inclusion of naphthalene produces a harder resin which is not readily attacked by petroleum distillates.[14]

These resins are insoluble in acids, alkali and ethyl alcohol and are not affected by hot 15% sodium chloride solution. Coating compositions derived from such resins could be used with advantage in marine work and chemical plants, in the treatment of railroad ties and telephone poles. Stains, varnishes, and lacquers have been prepared from these resins using *o*-dichloro benzene and *p*-Cymene as thinners. Satisfactory black, pliable coating composition can also be prepared without the use of extraneous pigments. These resins cannot be brought to the infusible state by heat and pressure treatment.[14]

(ii) *Hydration:* A simple, elegant and remarkable catalytic hydration of *p*-Cymene of great technical importance has recently been discovered by Schwartz.[15,16,17] In essence, it involves the saturation of the three double bonds resulting in camphor in a rather unusual manner.

The catalyst recommended is a mercury compound, *e.g.*, HgO or $HgCl_2$, or fatty acid salt, *e.g.*, sodium stearate, and the reaction is preferably carried out in a mutual solvent, *e.g.*, methyl alcohol, and at temperatures

* In this country from Indian Turpentine Oils.

above 35°, particularly at the boiling temperature. Modifications of the process consist in carrying out the reaction under 10 atmospheres pressure in the absence of solvent, and also in vapour phase.

(iii) Thermal fission : Cracking p-Cymene at 300°-450° with activated bleaching earths produce toluene and propylene,[18] *e.g.*, with 'tonsil' and at 420°, 60·5% toluene, besides 10% unchanged p-Cymene, saturated hydrocarbons (1·6%; b.p. 50°-60°, and 2%; b.p>180°) and 25% gas (80% propylene) is obtained.[19] Other methods[20,21] cover the production of toluene and propylene using a catalyst comprising of alumina and silica.

Selective elimination of a methyl group from the isopropyl residue as methane has been effected by Ostromisslensy and Shepard[22,23] by passing the hydrocarbon admixed with carbon dioxide through a tube at 650° : 40-50% yield of 4-methyl styrene is thus obtained. This is further investigated in detail by Breneck and Muller[24] who used iron, copper and aluminium catalysts. It is possible under suitable conditions to obtain 62% conversion into the styrene.

The selective dehydrogenation of p-Cymene into 4-α-dimethyl styrene achieved by Balandin and co-workers[12] is a recent contribution to the subject and marks an important advance. At 625°, with vanadium pentoxide as a catalyst, optimum conversion (63·4%) into the styrene takes place in presence of two mols of carbon dioxide. Improvements[25] of this process consist of reducing the partial pressure of p-Cymene by mixing with carbon dioxide and carrying out the reaction at reduced pressures and at lower temperatures, *e.g.*, 500°.

Conclusion : The utilisation of p-Cymene in the past for the production of synthetic thymol and menthol is well known. As indicated above, varieties of products could be obtained from p-Cymene, and it is hoped that this review will stimulate further investigations on the commercial utilisation of this important raw material for production of many useful substances.

1. Fr. Fitcher and Jacques Meyer, *Helv. Chim. Acta.*, 1925, **8**, 285. 2. C. E. Senseman and J. J. Stubbs, *Ind. Eng. Chem.*, 1931, **23**, 1129. 3. H. N Stephens, *J. Amer. Chem. Soc.*, 1926, **48**, 2920. 4 H. N. Stephens, *ibid.*, 1926, **48**, 1824. 5. C. E Senseman and J. J. Stubbs, *Ind. Eng. Chem.*, 1932 **24**, 1184. 6. R. C. Palmer, *ibid.*, 1942, **34**, 1028 7. R. C. Palmer and C. H. Bibb (to Newpor Industries, Inc.), *U. S. Pat.*, 1942, 2,302,462. 8. —,— (to Newport Industries, Inc.), *Ibid.*, 1942, 2,302,466. 9. Tunghna Kuan, *J. Chem. Soc. Japan*, 1931, **52**, 800. 10. S. V. Hintikka, *Ann. Acad. Sci. Fennicæ.*, 1923, **19A**, No. 10, 6. 11. R. C. Palmer and C. H. Bibb (to Newport Industries, Inc.), *U. S. Pat.*, 1944, 2,345, 625. 12. A. A. Balandin, G. M. Marukayan and R. G. Seimovich., *Compt. rend. acad. Sci. U. R. S. S.*, 1943. **41**, 67. 13. James K. Dixon (to American Cyanamid Co.) *U. S. Pat.*, 1945, 2,376,310. 14. P. H. Groggins., *Ind. Eng. Chem.*, 1928, **20**, 597. 15. F. Schwartzt *U. S. Pat.*, 1945, 2.389,389. 16. F. Schwartzt *Brit. Pat.*, 1943, 554,636. 17. —, *Swed. Pat.*, 1947, 118,286; *Chem. Abstracts*, 1948, **42**, 222. 18. Karl Schollkope, *U. S. Pat.*, 1920, 1,747,604. 19. Rheinische Kampfer-Fabrik, G. M. B. H., *Ger. Pat.*, 1928, 483,640. 20. Kungl Armeforvaltningens Artilleri Department (K. E. Skarblom, inventor), *Swed. Pat.*, 1935, 84,830 ; *Chem. Abstracts*, 1936, **30**, 6389. 21. G. Ljunggren (Försvarsväsendets Kemiska Anstalts Forskningslab., Stockholm). Finska Kemistsamfundets. *Medd.*, 1945. **54**, No 1/2, 12 ; *Chem. Abstracts*, 1947, **41**, 3684. 22. I. Ostromisslensky and M. G. Shepard (to Naugatuck Chemical Co.), *Brit. Pat.*, 1924, 232,919. 23. I. Ostromisslensky and M. G. Shepard, *U. S. Pat.*, 1924, 1,552, 875. 24. Hans Breneck and Hans Friedrich Muller, *Ber.*, 1942. **75B**, 554. 25. A. A. Balandin, G. M. Marukayan and R. G. Seimovich, *U. S. S. R. Pat.*, 1945, 64,222 ; *Chem. Abstracts*, 1946, **40**, 4715.

OSCAR EDWARD MEINZER*

IN the passing away of Dr. Oscar Edward Meinzer, the world has lost an eminen Geologist and a great authority on Ground-Water Hydrology. His famous treatise "The Occurrence of Ground Water in the United States with a discussion of Principles" published as Water Supply Paper No. 489 by the U. S. Geological Survey in 1923, and his numerous other papers on Hydrological investigations, specially on ground-water problems, contributed to the Governmental publications and Scientific and Engineering Journals, constitute a series of valuable references to Geologists and Hydrologists all the world over.

Dr. Meinzer was born on November 28, 1876, and hailed from a country farm in the State of Illinois. After a distinguished career at the College, he entered the U. S. Geological Survey in 1906 where he served for 40 years until his retirement in 1946. Through these long years of patient and able work, Dr. Meinzer has systematized the knowledge of the occurrence and principles of recovery through wells and springs of the supplies of water which are hidden in the rock formations. He was the leader in the development of ground water for useful purposes. He investigated the Geology and ground water resources in the arid valley regions of the Western States of U. S. A. These valleys were then sparsely populated or desert areas, but have since become prosperous through irrigation from wells developed as a result of his investigations.

Dr. Meinzer was a member of numerous scientific societies. He was the past President of the Society of Economic Geologists, and the Washington Academy of Sciences, and other institutions. At the time of his death he was the President of the American Geophysical Union. He had been awarded the William Bowie Medal in 1943.

Dr. Meinzer was a man of varied interests. He was a student of Philosophy and maintained a searching interest in Religion.

It is reported that Dr. Meinzer was apparently in good health and spirits upto the day of his death, June 14, 1948, when he quietly passed away during an afternoon nap. Thus came the peaceful end of a great career.

M. B. R. RAO.

* Published with the permission of the Director, Mysore Geolgical Department. A detailed Obituary Notse has been published on the opening pages of the *Transactions of the American Geophysial Union.*, August 1948, **29**, No. 4. from which the material for this hort noter hos been obtained.

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A NOTE ON THE RELIABILITY OF TESTS*

Reliability and validity are two of the most important aspects of psychological tests (intelligence Tests and Aptitude Tests, etc.). The most common method utilized to evaluate the reliability of tests is the split-half method.[1] The test is split into two halves in some way (*e.g.*, the odd items forming one half and the even ones the other half) and the coefficient of correlation between scores on them is worked out. This coefficient is taken to be a measure of the reliability of the test, and is defined as the reliability-coefficient of the test.

But there is a certain amount of arbitrariness in this method, in the sense that the splitting can be effected in more than one way. Actually there are $n/2\left(\frac{n}{2}\right)^2$ different ways of splitting a test of n items into two halves. Each of these ways of splitting the test gives its own estimate of the reliability-coefficient of the test, and there is no reason to suppose that each of these estimates must be the same. Hence for a test of n items the reliability coefficient worked out by one arbitrary splitting process is only one value chosen out of $n/2\left(\frac{n}{2}\right)^2$ values lying near it.

To rectify this defect in the split half method Messrs. Kuder and Richardson[2] worked out a method which leads to unique values of the reliability-coefficient. Their formula is

$$r = \frac{n}{n-1}\left(\frac{\sigma^2 - \Sigma pq}{\sigma^2}\right)$$

where

r = reliability of the test
n = number of items in the test
σ = standard deviation of the test
p = proportion of subjects passing my item
q = I-p
Σ = Summation taken over all items in the test.

We can now put a lower limit to the value of the reliability-coefficient of tests. For, suppose there are 100 items in a test, and suppose at worst the scores lie between 50 and 98 (a pretty narrow range) ; then because of normal distribution of scores, the standard deviation σ can easily be assumed to be about 8. Further the greatest value of $pq = \frac{1}{4}$. Hence the Kuder-Richardson formula gives

$$r > \frac{100}{99}\left(1 - \frac{100}{4 \times 8 \times 8}\right),$$

which is $> 0{\cdot}5$.

Hence a test of fairly big size, whose reliability-coefficient is less than 0·5, *is not good for use and must be rejected.*

Although from theoretical considerations Kuder-Richardson formula is an improvement over the split-half method; yet its application in actual practice is a time-taking matter; for the term $\Sigma\, pq$ takes long to be evaluated. It would be welcome, therefore, if we could work out a formula which gives the reliability quickly even though approximately.

In the Kuder-Richardson formula let us replace $\frac{n}{n-1}$ by unity, and take $\sigma = \frac{n}{6}$. The value of pq lies between 0 and ¼, so that $\Sigma\, pq$ may be taken to be $\frac{n}{6}$. With these assumptions the reliability

$$r = 1 - \frac{n/6}{(n/6)^2} = \frac{\sigma - 1}{\sigma},$$

for $\frac{n}{6} = \sigma$.

This formula is independent of the term $\Sigma\, pq$ and is, therefore, very quick in giving the reliability of tests. It may be noted that bigger the size of the test, better will be the approximation given by this formula; for bigger is n, nearer to 1 is $\frac{n}{n-1}$.

For purposes of verification I have already applied the formula elsewhere[3] and found that the approximation given by this formula is correct upto the first place of decimal. Such an approximation is often quite satisfactory as far as reliability coefficients are concerned.

Ministry of Education, Government of India, Simla, *September* 19, 1948.

P. D. SHUKLA.

1. Garret, H. E., *Statistics in Psychology and Education*, 1946, p. 313. 2. Kuder, G. F. and Richardson, M. W., The Theory of the Estimation of Test Reliability" *Psychometika*, 1937, **II, 3,** 151-60. 3. Shukla, P. D., "Some Statistical Studies about Civil Selection Boards Abstract," *Proc. Indian Sci. Congress*, Delhi, 1947.

* This note was read in the Indian Science Congress Session at Patna, in January 1948.

While considering the Kuder-Richardson formula

$$r = \frac{n}{n-1}\left[\frac{\sigma^2 - \Sigma pq}{\sigma^2}\right] \qquad (1)$$

the author suggests that we can assume that $\frac{n}{n-1}$ approaches unity as n becomes larger and larger and also that we can replace σ by $\frac{n}{6}$ and $\Sigma\, pq = n/6$. The value of pq lies between 0 and 1/4 and the reasons for assuming $\Sigma\, pq = n/6$ is not very clear, apart from the arithmetical ease in the further simplification of (1). Since in (1) the term $\Sigma\, pq$ is subtracted, it is better if we assume the maximum value of $\Sigma pq = n/4$ and proceed as suggested in this paper. The value of r on simplification becomes the minimum and the formula (1) reduces to

$$r = \frac{\sigma - 1{\cdot}5}{\sigma}.$$

If this value of r can be assumed to be reliable, it will be so whatever be the values of p and q, while the simplifications suggested by the author will be reliable only when $0 < \Sigma\, pq < n/6$. Besides, this new formula has got all the advantages which is claimed by the author for his suggested formula.

M. C. S. AND N. S. N.

Bangalore, *October* 19, 1948.

ON EINSTEIN'S GENERALIZED THEORY OF GRAVITATION

A PAPER, bearing the same title as the present communication, was recently communicated by us to the National Institute of Sciences of India. We have discussed in it the field equations of the generalized theory* and outlined a method of successive approximations for working out the interaction between a gravitational field and an electromagnetic field. The computation of interaction terms is an extremely laborious task and, so far as we know, has not been carried out yet. The results that are given below seem to be new and of considerable interest.

The theory is based on a Hermitian tensor g_{ik}:

$$g_{ik} = a_{ik} + \sqrt{-1}\, b_{ik},\ a_{ik} = a_{ki},\ b_{ik} = -b_{ki}. \qquad (1)$$

We consider a pure gravitational field as given by

$$a_{11} = a_{22} = a_{33} = -(1+m/2r)^4,$$
$$a_{44} = (1-m/2r)^2\,(1+m/2r)^{-2},\ a_{ij} = 0,\ i \neq j \qquad (2)$$

and a pure electromagnetic field as given by

$$b_{13} = b_{34} = \phi,\ b_{12} = b_{14} = b_{23} = b_{24} = 0,$$
$$\phi \equiv A \cos \frac{2\pi}{\lambda}(x - t), \qquad (3)$$

in the usual notation. In the complex field unifying the two a_{ij} is modified by ϕ and b_{ij} by m. The exact nature of the interaction of the two fields is certainly very complicated. Our computations show that the usual Maxwell equations are modified as follows:

$$\begin{aligned}
-\frac{\partial E_z}{\partial y} + \frac{\partial E_y}{\partial z} - \frac{\partial H_x}{\partial t} &= \frac{2\phi m z}{r^5},\\
-\frac{\partial E_z}{\partial z} + \frac{\partial E_x}{\partial x} - \frac{\partial H_y}{\partial t} &= 0,\\
-\frac{\partial E_y}{\partial x} + \frac{\partial E_x}{\partial y} - \frac{\partial H_z}{\partial t} &= -\frac{2\phi m x}{r^5},\\
\frac{\partial H_x}{\partial x} + \frac{\partial H_y}{\partial y} + \frac{\partial H_z}{\partial z} &= -\frac{2\phi m z}{r^5}.
\end{aligned} \qquad (4)$$

The components of the electric current-and-density vector are found to satisfy, to the same degree of approximation, the following equations—

$$\begin{aligned}
\Box\ \rho + \frac{12mxy}{r^5}\ \phi_1 &= 0,\\
\Box\ \sigma_x + \frac{12mxy}{r^5}\ \phi_1 &= 0,\\
\Box\ \sigma_y + \frac{12m}{r^5}(y^2 - z^2)\phi_1 &= 0,\\
\Box\ \sigma_z + \frac{24myz}{r^5}\ \phi_1 &= 0,
\end{aligned} \qquad (5)$$

where $\square$ stands for $\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2} - \frac{\partial^2}{\partial t^2}$ and ϕ_1 for $\frac{\partial \phi}{\partial x}$. It can be verified that

$$\square \left(\frac{\partial \sigma_x}{\partial x} + \frac{\partial \sigma_y}{\partial y} + \frac{\partial \sigma_z}{\partial z} + \frac{\partial \rho}{\partial t} \right) = 0 \qquad (6)$$

We have similarly obtained the ten gravitational field equations showing how the gravitational potentials a_{ij} are modified on account of the electrostatic and electromagnetic potentials. The details and further deductions will be published elsewhere.

Benares Hindu University, V. V. NARLIKAR.
October, 19, 1948. RAMJI TIWARI.

* Einstein, A., "A Generalized Theory of Gravitation", *Rev. Mod. Phys.*, 1948, **20**, 35. A reference may also be made to the earlier papers in *Ann. Math.*, 11 (1945), **46**, 578 and (1946), **47**, 731.

ON HOTELLING'S WEIGHING PROBLEM

IN the June issue of the *Annals of Mathematical Statistics*, Kempthorne approached the construction of the orthogonal matrix X required in Hotelling's weighing design through fractional replicates, the original discussion of which was given by Finney. While referring to weighing three objects, Kempthorne mentions about the three-fourth replicate of a 2^n factorial experiment without giving any details. It has been shown that the efficiency of such designs bears a constant ratio to that of the designs given by the completely orthogonalised matrices.

In a three-fourth fractional replicate, the treatment contrasts will divide themselves into groups of 4 contrasts each and in each such group only three contrasts will be independent. The contrasts in any group will be orthogonal to all the contrasts in the other groups but non-orthogonal to one another within the group itself. One contrast in the group of 4, preferably that due to the highest order interaction may be left out. The matrix X'X will take in this case the following form:

$$\begin{bmatrix} x & a & a & 0 & 0 & 0 & .. \\ a & x & a & 0 & 0 & 0 & .. \\ a & a & x & 0 & 0 & 0 & .. \\ 0 & 0 & 0 & x & a & a & .. \\ 0 & 0 & 0 & a & x & a & .. \\ 0 & 0 & 0 & a & a & x & .. \\ . & . & . & . & . & . & .. \end{bmatrix}$$

where the order of the matrix $N = (3/4)\,2^n$ is of the form $3t$ ($t = 2^{n-2}$) and $x = 3 \cdot 2^{n-2}$) $a = -\frac{1}{2}2^n + 2^{n-2} = -2^{n-2}$. The value of the above determinant $= (x-a)^{2t}\,(x+2a)^t$ and that of the determinant suppressing the first row and the first column $= (x-a)^{2t-1}\,(x+a)\,(x+2a)^{t-1}$. Hence the variance factor $a^{ii} = (x+a)/[(x-a)\,(x-2a)] = \frac{1}{2^{n-1}}$, substituting for x and a.

The variance of each estimate will therefore be $\sigma^2/2^{n-1}$, whereas the variance of the estimates given by an orthogonal matrix of the order $N = (3/4)\,2^n = 3 \cdot 2^{n-2}$ will be equal to $\sigma^2/3 \cdot 2^{n-2}$. The ratio of the two variances $= 2/3$. Therefore, the efficiency of a design given by a three-fourth replicate would always bear the constant ratio of 66·66 per cent of the efficiency of a design given by a completely orthogonal matrix. In general, when the fraction is of the type $(2\beta-1)/2^\beta$ of 2^n, ($\beta = 1, 2, \cdots n$), the variance of an estimate is $\sigma^2/2^{n-1}$, the same as above. When a completely orthogonalised matrix is available, the variance of an estimate will be $\sigma^2/[2^{n-\beta}\,(2\beta-1)]$. The ratio of the two variances $= 2\beta^{-1}/(2\beta-1)$, which shows how the efficiency of the weighing design decreases with the increasing value of the fraction. When $\beta = 1$, i.e., in a half replicate, the efficiency is cent per cent. The value of the fraction is never less than ½.

Pusa, Bihar, K. S BANERJEE.
November 13, 1948.

1. Harold Hotelling, "Some improvements in weighing and other experimental techniques," *Annals of Math. Stat.*, 1944, **15**, 297-306. 2. K. Kishen, "On the design of experiments for weighing," *Ibid.*, 1945, **16**, 294-301. 3. A. M. Mood, "On Hotelling's weighing problem," *Ibid.*, 1946, **17**, 432-446. 4. R. L. Plackett and J. P. Burman, "The design of optimum multifactorial experiments," *Biometrika*, 1946, **33**, 305-325. 5. O Kempthorne, "The factorial approach to the weighing problem" *Annals of Math. Stat.*, 1948, **19**, 238-245. 6. D. J. Finney, "The fractional replication of factorial arrangements," *Annals of Eugenics*, 1945, **12**, 291-301. 7. K. S. Banerjee, "On the design of experiments for weighing and making other types of experiments," *Science and Culture*, 1948, **13**, 344. 8. —, "Weighing designs and balanced incomplete blocks," *Annals of Math. Stat*, 1948, **19**, 394-399.

ON A CERTAIN BASIC THEOREM IN GEOMETRY

IN a recent issue of this journal,[1] I proposed a basic theorem in Geometry as a sort of mock challenge to see if any rigorous geometrical thinking comes out of it. The result was a heap of unnecessary discussions which clearly showed failure to perceive the point in my theorem. If one had recollected David Hilbert's Foundations of Geometry or recognised the need for a definition characterising the interior of an angle formed by two half-rays, the theorem would have been easily disposed of. David Hilbert does not give a definite construction for an interior point of an angle, though he mentions[2] that the half-rays together with their intersection divide the remaining points of the plane containing them into two regions, one of which may be characterised as the interior of the angle from the property that the segment joining any two points of it lies entirely within the region. I give below a construction for determining an interior point.

Let P be any point on a half-ray h and Q any point on a half-ray k, proceeding from a point O. Draw parallels PR, QR to OQ, OP respectively. Then R is an interior point of the angle (h, k).

More briefly, every vertex of a parallelogram is an interior point of the opposite angle.

The above statement may be treated as an axiom for the purpose of my theorem. It is, however, capable of rigorous proof with the help of Hilbert's axioms of order, congruences and parallels.

To proceed to my plane problem, let the given straight lines intersect at O, and R be any point not incident on either of these lines. If S, T be the feet of the perpendiculars on the given straight lines, it is required to show that the angle SRT is the supplement of the angle in which R lies, *viz.*, that which is given by my axiom as the angle POQ where P lies on OS and Q on OT and RPOQ is a parallelogram. Here O-S, OT do not signify half-rays but whole straight lines.

The theorem immediately follows if the given straight lines cut at right angles. When the given lines do not cut at right angles, let α be the measure of the acute angle between them.

The triangles RPS, RQT are similar right-angled triangles, since the acute angles RPS, RQT, by the property of parallels, must each be equal to α;

$$\text{further } \sin\alpha = \frac{RS}{RP} = \frac{RT}{RQ} = \frac{RT}{OP},$$

as OP=RQ from the parallelogram RPOQ. (1)

Again, since S, T lie on the circle on OR as diameter, $ST = OR \sin S\hat{O}T = OR \sin\alpha$ (whether $S\hat{O}T = \alpha$ or $\pi - \alpha$) (2)

From (1) and (2), $\frac{RS}{RP} = \frac{RT}{OP} = \frac{ST}{OR}$ which proves that the angle SRT is equal to the angle RPO which is the supplement of the angle POQ.

The theorem is therefore proved.

Cor. R lies in the acute angle or the obtuse angle between the given lines according as

$$ST^2 \lessgtr SR^2 + RT^2.$$

In particular, if the given lines be $x\cos\alpha_i + y\sin\alpha_i = p_i$ $(i = 1, 2)$ and R $(0, 0)$, then S is $(p_1\cos\alpha_1, p_1\sin\alpha_1)$ and T is $(p_2\cos\alpha_2, p_2\sin\alpha_2)$ and the origin will be in the acute or obtuse angle between the lines according as

$$(p_1\cos\alpha_1 - p_2\cos\alpha_2)^2 + (p_1\sin\alpha_1 - p_2\sin\alpha_2)^2 \lessgtr p_1^2 + p_2^2$$

i.e., $p_1 p_2 \cos(\alpha_1 - \alpha_2) \lessgtr 0$.

The corresponding three-dimensional result is an immediate deduction from the above if one considers the traces of the given planes on the plane through the given point perpendicular to them.

N.B.—No figure is necessary to follow the above proof. Everything follows logically from the axioms and known theorems. My axiom clarifies the location of an interior point of an angle and states in an idealised form a perceptual fact.

A. A. KRISHNASWAMI AYYANGAR.

Andhra University,
Waltair,
December 7, 1948.

1. *Curr. Sci.*, 1948, **17**, 233. 2. David Hilbert, (Translated by Townsend), *Foundations of Geometry*, 2nd Edition, 1910, 14.

NUCLEIC ACID ANTAGONISM OF PENICILLIN BACTERIOSTASIS

In a 'careful re-investigation' of our experiments[1] on the antagonistic effect of nucleic acid on the bacteriostatic action of penicillin, Ganapathi *et al.*,[2] report that they have failed to repeat our results and offer an explanation for the observations we have made. If the contention is that nucleic acid had no effect on the bactericidal action of penicillin as the title of their report would imply and as repeated in the text (para 4) we have nothing to state except to add that it is well known that organisms which have undergone bactericide by penicillin or any other drug cannot be revived and restored to life by any known process, whatsoever, since the organisms would have lost their lives under the influence of the drug. However, in bacterial cultures kept in the presence of bacteriostatic concentrations of penicillin whose action is reputed to be essentially bacteriostatic, under the conditions, instantaneous death of the organisms never result but only a temporary cessation of respiratory and reproductive processes resulting in inhibition of growth and multiplication. An agent which can sidetract, annihilate or by some means bring down the effective concentration of penicillin when added to the culture, will stimulate almost a sudden restoration of viability and consequently growth is imperative. Our experiments relate only to this latter condition and we repeat our claim. Under the influence of rather high concentrations of penicillin as for example two to sixteen units per ml. not only the organisms suffer death but also undergo lysis. A lack of appreciation of the bacteriostatic and bactericidal effects in relation to drug concentration has brought all the difference and in mode of action studies of drugs, one has very little use of dead organisms. There is no mention in the note about the actual value of the minimum bacteriostatic concentration of penicillin and remembering that the inoculum is comparatively small one can see that even 0·05 unit per ml. is above the bacteriostatic range, as otherwise, there is absolutely no reason why growth did not occur in Ganapathi, *et al.*'s cultures.

In Benedict, *et al.*'s paper[3] quoted by Ganapathi, *et al.* on page 94 is stated 'these data show the rapid increase in stability of penicillin as the hydrogen-ion concentration decreases (pH 2·0 to 6·0) with subsequent increase in decomposition as the concentration of the hydroxyl ions becomes greater, and this fact is illustrated on page 93 of the same paper. This means that penicillin ought to be stable in cultures which reach pH 5·2 to 5·5 at 37° C. But Ganapathi, *et al.* state that at this pH and when incubated at 37° C. small concentrations of penicillin are fairly easily destroyed. We would like to ask (i) if penicillin is not destroyed at pH 5·2 to 5·5 as the observations of Benedict, *et al.* claim is it not antagonism of penicillin action which added nucleic acid exerts with subsequent growth in our cultures and (ii) if penicillin is destroyed as Ganapathi *et al.*, claim, why they failed to see growth in the presence of nucleic acid, at least visual

turbidity in the tubes containing lower concentrations of penicillin particularly when in the presence of nucleic acid alone there is as much depth of turbidity due to growth as is indicated by four *plus* signs. There is thus a clear contradiction between the observation and explanation which Ganapathi, *et al.*, have described. Thirdly the statement in the last paragraph of the note Ganapathi *et al.* imply that penicillin cannot be destroyed at pH 7·0 under the conditions they describe. It is now well known that as the pH tilts to alkalinity penicillin gets progressively destroyed.

It is also well known that penicillin acts best on young actively growing cells. Since the optimum growth of pathogenic organisms happens to be 37° C., penicillin is more active at 37° C. than at lower temperatures on bacteria. In the case of insensitive bacteria like *Esch. coli* requiring high minimum inhibiting concenrtations of penicillin, even very high concentrations of nucleic acid 1/100 cannot reverse the inhibtion brought about by penicillin, while this is actually achieved by the magnesium salt of nucleic acid.[4] We have indeed found that the organisms which had become nonviable by contact with bacteriostatic concentration of penicillin were actually rendered viable by added nucleic acid[1] a fact which clearly indicates the lack of any correlation between pH effects and capacity of nucleic acid to antagonise penicillin bacteriostasis. It may thus be seen that under the conditions used, pH effects and temperature effects do not orientate the influence of nucleic acid on penicillin bacteriostasis and our conclusion that nucleic acid reverses the bacteriostatic effect of penicillin on *Staph. aureus* seems quite warranted. It is interesting to note in this connection that Pratt and Dufrenoy[5] have offered a very sound and convincing explanation of our observations.

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Bangalore,
October 6, 1948.

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WE have carefully considered the note of Pandalai and George and have to report that our original contention stands. In the note of Pandalai and George, it is claimed that "they have shown that nucleic acids possess the property of antagonising penicillin action" and they have "suggested that penicillin interferes with certain phases in the metabolism of the organisms where nucleic acids feature either as metabolites helping cell division or function as respiratory catalysts or both." If this sweeping assertion be true, then nucleic acids should antagonise the action of penicillin *in vitro* in a very significant way. We have shown that this is not the case. Our experiments have been misinterpreted by Pandalai and George. When the broth contains penicillin in concentrations ranging from 0·05 units to 16 units per ml. *along with* nucleic acid or its sodium salt in concentrations ranging from 1/10000 to 1/200, we could observe no reversal of bacteriostatic action against *Staphylococcus aureus*. When nucleic as the free acid is used, in the borderline concentration of 0·05 units per ml., there is an apparent slight reversal of penicillin bacteriostasis, which we have suggested to be due to the destruction of penicillin and consequent lowering of the concentration to an extent at which it is not bacteriostatic. Pandalai and George now question this destructive action of nucleic acid. We have experimental evidence to support our conclusion. To the broth was added in one case penicillin *plus* sodium salt of nucleic acid in the other penicillin *plus* free nucleic acid. These were incubated at 37° C. overnight and the penicillin concentration in the two sets of tubes estimated by the iodine titration method. In the broth containing sodium salt of nucleic acid about 90% of the added penicillin could be recovered, while in those containing free nucleic acid only 40 to 50% of the added penicillin could be recovered. Thus, when in the borderline concentration of 0·05 units per ml. about 50% of the penicillin is destroyed, the remaining quantity is not sufficient to show the full degree of bacteriostasis. Where higher concentrations of penicillin are used, even after the destruction of 50% of the added penicillin, there is still enough penicillin left over in the broth to show bacteriostasis. There is no contradiction in the result, as has been suggested by Pandalai and George. All the results reported by Pandalai and George are due to this destruction of penicillin by nucleic acid and no experimental evidence has been advanced to prove their elaborate theory.

Pandalai and George claim that cultures rendered nonviable by "prolonged contact with penicillin" are rendered viable by the addition of nucleic acid. According to their experiments, the cultures have been kept in contact with penicillin for 3 and 6 hours only. We have repeated the experiment and have found that under these conditions all the organisms are not rendered nonviable. In our experiments, one mm. loopful of a 24-hour old culture of *S. aureus* was inoculated into 5 ml. of standard broth containing different concentrations of penicillin. These were incubated for 3, 6 and 18 hrs. at 37° C and at the end of these periods, 0·1 c.c. of these cultures were transferred to 5 ml. of sterile broth and these tubes were incubated for 24 hours. Thus by reducing the concentration of penicillin, the viable organisms present are allowed to grow. We have found growth in all the tubes in which penicillin was used in concentrations of 0·1 to 0·3 units per ml. in the original tubes. Thus it is clear that even with 18 hours contact with penicillin, all the organisms do not become nonviable as claimed by Pandalai and George. So the organisms that are left over start multiplying when nucleic acid is added to the broth which destroys penicillin.

Thus Pandalai and George have not produced any proof to support their contention They refer to the review of Pratt and Dufrenoy ; these authors do not confirm the observations of Pandalai and George ; they only comment on them. We primarily question the correctness of the results of Pandalai and George.

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SEX INHERITANCE IN *LUFFA ACUTANGULA*

As a result of single plant selection studies, some true breeding cultures for various characters have been established from the local material of *Luffa acutangula* and two of such selections which differed in their sex condition formed the basis of the present genetical studies, *viz.*, *Jhingli No. 1* which is monœcious and *Satputia No. 1*, hermaphrodite.

Crossing was attempted both ways, but it succeeded with *Satputia No. 1* as female only. Sixteen F_1 hybrids were raised, all of which proved to be monœcious (producing male and female flowers on the same individuals). Very rarely hermaphrodite flowers were also observed on the same individuals. Pollen formation and seed setting were found to be quite normal in these hybrids.

F_2 generation was raised from selfed seeds of four different F_1 hybrids. In all 266 hybrids were raised and studied and they could be distinctly classified into three different classes (Table I), as explained below:

(*a*) *Monœcious plants*: This class of hybrids showed the sexes in different flowers, male and female, on the same individuals. They exhibited variation in two directions, *viz.*, (1) in the stage at which the female elements appeared, as in some of them the female flowers appeared soon after the male ones, whereas in others at a very late stage, and (2) in the appearance of hermaphrodite flowers in addition to male and female ones. In some of them such flowers appeared in greater number than in others.

(*b*) *Female plants*: This class of hybrids produced female flowers only.

(*c*) *Hermaphrodite plants*: This class of hybrids produced hermaphrodite flowers only.

TABLE I

Segregation in F_2 population for different sex forms in a varietal cross of L. acutangula

	Segregation in F_2 generation			Total No. of F_2 hybrids
	Monœcious	Female	Hermaphrodite	
Observed	203	51	12	266
Expected on 12 : 3 : 1	199·5	49·875	16·625	266

$X^2 = 1{\cdot}372$; $p > 0{\cdot}50$

The F_2 segregation indicates that there are possibly two independent factor pairs, responsible for sex inheritance in this cross, designated as *AA BB* : The factor pair *AA* controls the expression of sex elements, both male and female, distributed in separate flowers on the same plant (monœcious condition). Where this factor for monoecious condition is lacking (in plants which are *aa*), the plant would be hermaphrodite, but this expression is influenced by the other factor *B* which controls the expression of female sex only and in its absence the plant again becomes hermaphrodite. But the factor *B* is ineffective in the presence of *A* which may be said to be epistatic to *B*. Sex in plants which are *aa* is then exclusively determined by *B*. Thus in the absence of *A* the hybrids with the constitution *aa BB* or *aa Bb* would be female plants and those with *Aa* or *AA* would be monœcious whether *B* is present or absent. In the absence of both *A* and *B*, the plant with the constitution *aa bb* will be hermaphrodite (the double recessive genotype). The constitution of the parents will thus be *aa bb* in the case of *Satputia No. 1* and *AA BB* in the case of *Jhingli No. 1*.

In short, sex inheritance in this cross is controlled by two independent factor pairs, one of which determines the expression of both sexes, whereas the other one controls female sex only, the first one being epistatic in action. In the absence of both, an individual becomes hermaphrodite.

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PRODUCTION OF *P*-CYMENE FROM CARENE*

CARENE is a raw material for the production of *p*-Cymene (i).[1,2,3,4] The work reported in this note is on the disproportionation of this hydrocarbon to (i) over Fe_2O_3-gypsum catalyst.

The catalyst is prepared as follows: 17·5 gm. of $FeSO_4 . 7 H_2O$ is dissolved in 500 c.c. water; added to the solution a few c.c. con. nitric acid and gradually heated. To the fully oxidised solution added ammonium chloride and then dilute ammonia carefully with stirring, until the precipitate is permanent. The precipitate is washed by decantation several times with water. Mixed in 300 gm. of well-washed gypsum pieces, 8-10 mesh size. It is then dried on a water-bath with constant stirring, and finally ignited to the oxide stage in a fireclay crucible.

Carene (b.p. 163-68° C./745 mm. d_{18}^{15} : 0·8468, n_D^{20} : 1·4716) fractionally distilled from Indian turpentine (*P. longifolia*), is passed over the catalyst bed, 60 cm. long, occupying a total space of 234·0 c c. ; time of contact is 3 hours for 100 c.c. carene.

The pyrogenic unit is described in a previous communication.[4]

Identification of (i) is by oxidation by chromic acid to terephthalic acid (dimethyl ester, m.p. 140° C.).

Table I gives the analysis of the major fraction containing (i) after one fractionation ; Table II gives the result of the fractional

distillation of the pyrolysates. Young's 8-pear pyrex column is used in all cases.

TABLE I
Analysis of the fraction boiling 173-78° C./745 mm.

	Temperature of pyrolysis ±15° C.	% Yield on the wt. of carene fed	Iodine value (Wijis method)	d_{15}^{15}	n_D^{20}
1	300° C.	28·0	84·0	0·8572	1·4820
2	350° C.	23·6	77·0	0·8627	1·4875
3	400° C.	20·5	79·7	0·8631	1·4860
4	500° C.	14·9	71·3	0·8805	1·5013

TABLE II
Analysis of the pyrolysates.

	B.P. C. 745 mm.	% yield on the wt. of carene			
		Pyrolysis temperature ±15° C.			
		300° C.	350° C.	400° C.	500° C.
1	Gases	15·0	11·8	8·9	33·0
2	–75°	0·5	0·9	2·2	4·1
3	75–100°	2·0	0·9	1·3	2·0
4	100–120°	1·0	0·9	0·4	3·7
5	120–143°	1·5	1·8	4·0	7·5
6	143–163°	9·0	8·1	8·4	9·1
7	163–173°	30·0	38·1	37·5	11·5
8	173–178°	28·0	23·6	20·5	14·9
9	Above 178°	12·0	10·9	10·3	12·4
10	Losses, etc.	1·0	3·0	6·5	1·8

At 400° C. and 500° C. Fe_2O_3-gypsum is a more efficient catalyst than Pt-gypsum.[4] It yields purer crude (i) than that obtained with V_2O_5[4] or Pt-gypsum at 300°-500° C.

Thus the order of activity of the catalysts : partially-dehydrated gypsum,[4] Fe_2O_3-gypsum, Pt-gypsum and V_2O_5 : with respect to the purity of crude (i) produced is :

Partially-dehydrated gypsum > Fe_2O_3-gypsum > Pt-gypsum > V_2O_5.

Impregnation of gypsum with Fe_2O_3 or Pt does not increase its dehydrogenation power.

At 500° C., Fe_2O_3-gypsum catalyst exercises an aggressive effect on carene and yields over two and a half times the quantity of gaseous products than that obtained with partially-dehydrated gypsum.[4]

Lower fractions boiling from 120° C. to 173° C. give positive tests for (i) as evidenced by the formation of terephthalic acid when the samples are oxidised by chromic acid. Refractionation improved the yield of crude (i) by 30%.

This publication is delayed due to the political changes at Lahore.

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Lahore, BHARAT BHUSHAN.
October 8, 1948. M. L. JOSHI.

* The word 'carene' is purposely used. There is evidence that natural Δ^3 – carene is not quite homogeneous.[5,6,7]

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ON SOME PHYSIOLOGICAL PROPERTIES OF EXTRACTS OF WHEAT GRAINS

THE conditions generally necessary for successful seed germination are sufficient moisture as well as aeration and an appropriate temperature. According to Nelson[1] some kinds of seeds, *e.g.*, carrot and parsley, tolerate and indeed benefit from presoaking for 24 hours or even more, whereas a mass of soaking beet seeds can poison themselves in quite a short time unless the water is frequently changed. Evidently release of a poisonous substance from the seed is indicated. Duym, *et al.*[2] conclude, however, that the inhibiting effect of the extract from the seed balls of sugarbeet on the germination of Avena seeds is mainly due to the osmotic pressure of its salt content. Bonner, *et al.*[3] have found that the water extract of peas contains a leaf growth hormone. It now appears to be definitely established that seeds of maize, barley, rye and wheat contain free auxin (*cf.* Hatcher,[4] Avery, *et al.*,[5] Haagen-Smit, *et al.*[6]), which diffuses out into water medium.

The presence of salts or hormones in the water extract of seeds has interest from another point of view. It has been reported by Henkel, *et al.*[7] and also by Chinoy[8] from this laboratory that drought resistance is induced by alternately soaking wheat grains in water and drying prior to sowing. In view of the findings referred to above it is quite likely that some substances diffuse out from the seeds during soaking in water. With a view to investigating the causes underlying this effect of the water-soaking treatment we considered it worthwhile in the first instance to examine the properties of water extracts of wheat grains. Some of the observations made during the course of this study appear interesting and an account of the same is presented here.

Preliminary observations indicated that whereas the water extract of seeds of *T. Vavilovi* retarded the growth of the main root of germinating seeds of maize and wheat (sown in sand and moistened with extract), that from seeds of another variety, *viz.*, N. P. 165 had no such effect. A study of a number of varieties was, therefore, undertaken. As a test object the main roots of 15 germinating maize—var. Pusa yellow—seedlings (about 48 hours from sowing at room temperature when the main root was about 1·5 cm. long) were used. The seedlings were kept in petri-dishes with roots immersed in about 20 c.c. of distilled water or the extract and the lengths of the main roots

TABLE I

Test period in hrs.	Variety	Root growth in cm.		
		Distilled water	Extract	Ashed extract
15	Khapli	3·17±0·15	1·06±0·04	3·0 ±0·15
,,	N.P. 165	,,	2·76±0·14	3·25±0·22

Test period in hrs.	Variety	Distilled water	Extract (original)	Ether Extract	Residue insoluble in ether
18	Khapli	3·80±0·16	2·44±0·14	2·91±0·29	2·51±0·16

Test period in hrs.	Variety	Distilled water	Extract	Extract dried at 80° C.
18	Khapli	3·80±0·38	2·44±0·14	2·40±0·11

were measured again after about 15 hours. The difference in the growth made during the test period in distilled water and in the extract indicated the presence as well as strength of the inhibiting substance or substances. Except during actual measurement of length, the seedlings were always kept in the dark at room temperature. Temperature during the test period was not controlled and the test period also varied from 15 to 18 hours according to convenience. Since most observations are comparative these defects in the technique may not seriously affect the validity of the results.

The extract was obtained by soaking 200 or 10 gm. of air dry seeds in 30 c.c. of freshly boiled (and cooled) distilled water for 3 hours at room temperature. Before soaking, the seeds were washed 12 times with tap water, 8 times with distilled water, for 2 minutes with rectified spirit and finally 6 times with freshly boiled and cooled distilled water.

In Table II, column 5, are presented the results of tests with nine varieties of wheat from which it appears that extracts of *T. Vavilovi* and Khapli alone contained the inhibiting substance. The depressing effect of auxin on root growth is well known. Experiments were, therefore, undertaken to see what type of substance in the extract inhibited root growth. Seeds of Khapli alone were used for detailed study as it is difficult to raise a good crop of *T. Vavilovi* under Delhi conditions.

It was found on evaporating the extract to dryness on the water-bath that a brown sticky syrup with a sweet smell was left as a residue indicating caramelisation of sugar. The presence of sugar in the pea extract has been reported by Bonner, *et al.*[3] Root growth was, however, not retarded in 1% sucrose solution during the usual period.

That the inhibiting effect of the extract was not due to its salt content was determined by ashing the extract and testing the aqueous solution of the ash (*cf.* Table I). Apparently some organic substance other than sugar inhibited root growth. The data in Table I indicate that it was possible to extract the substance with ether, although not completely, from the dry extract. Data in Table I also indicate that the substance was thermostable (up to about 80° C.).

Split coleoptiles gave an inward curvature when immersed in the extract as they usually do under the influence of auxin. The roots grown in the extract also appeared thicker (*cf.* Thimann[9]). It is, therefore, presumed that the growth-inhibiting substance in the extract is hormonal in nature and is probably free auxin.

The difference between the varieties still remained to be accounted for. According to

TABLE II

Test period in hours	Variety	Days from sowing to flowering	Growth in cm.		
			Distilled water	Ordinary seed	Punctured seed
18	*T. Vulg.* N.P. 165	90	3·38±0·20	3·31±0·17	0·97±0·07
14	*T. Vulg.* C 13	90–100	2·77±0·22	2·16±0·17	1·45±0·05
,,	*T. Pyramidale*	110–120	2·77±0·22	2·39±0·20	0·99±0·12
15	*T. Dicoco.* Mindum	120–130	2·37±0·14	2·15±0·24	0·84±0·08
14	*T. Durum* Kubanka	130–140	1·95±0·24	2·09±0·09	0·50±0·06
17	*T. persicum* Persian Black	140–150	2·28±0·23	1·76±0·17	0·63±0·09
14	*T. Polonicum*	150–160	1·95±0·24	1·83±0·16	0·63±0·05
15	*T. Dicoco.* Khapli	100–110	2·77±0·15	1·22±0·07	..
16	*T. Vavilovi*	160–170	3·22±0·14	2·03±0·13	..

Hatcher,[4] in the rye grain the major proportion of auxin is concentrated in the aleurone layer. Seeds of the varieties whose extracts did not inhibit root growth were, therefore, soaked in water for about half an hour just to soften them and were then pricked at four places near the embryo with a pin with a view to puncturing the aleurone layer and testa. Extracts from such seeds were found to contain the inhibiting substance as seen from data in Table II, column 6.

It is evident from the data above that the inhibiting substance does not diffuse through the aleurone layer or testa (whereas salts and sugar do) when seeds of these varieties are extracted with water at room temperature —about 95° F. That the inhibiting effect was not due to salts was ascertained by testing the ashed extract.

It was possible to extract this substance by treating seeds of NP 165 with water at a temperature of about 80°C. on a water-bath for about half an hour. Evidently the aleurone layer and the testa became more permeable at this temperature. Conversely when seeds of Khapli were extracted with water at a lower temperature—about 50°F.—they yielded a much smaller quantity of the inhibiting substance.

In conclusion, the differential effect of water-soaking treatment at room temperature on the release of a hormone-like substance – presumably auxin—from grains of different wheats, as estimated by the 'root' test, is emphasized. It is possible that the more delicate 'Avena' test —which could not be carried out for want of equipment—might detect the presence of the hormone in extracts of those seeds which gave a negative result with the 'root' test. It is, however, felt that the quantitative difference in the yield of the substance between varieties would still persist. How far this differential effect would influence the subsequent performance of the varieties under different environments would appear to be worth consideration.

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November 1, 1948.

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V. S. MANI.

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THE SPECTRUM OF IODINE VII

ABOUT a decade ago, L. and E. Bloch and Felici[1] published a long list of lines due to highly excited Iodine in the region λ 200 to λ 1,000. They divided their data however, into seven groups denominated 2−, 2, 2+, 3−, 3, 3+ and 4, but not into I, II, III, IV groups familiar in spectroscopic notation. From group 4, they picked up two lines ν 515080 and ν 525925 and identified them as due to I VIII. Starting with the clue that their data contains lines of I V, VI and VII too, the writer made an attempt to pick up from the same, the doublets of I VII by way of partly clearing up the data for the solution of I III and I IV, which are in progress in this laboratory.

Table I, which shows the application of the so-called Irregular Doublet Law, helped in the identification.

TABLE I

Corresponding lines in Ag I-like spectra.

Spectrum	$5s^2S_{\frac{1}{2}} - 5p^2P_{\frac{1}{2}}$	$5s^2S_{\frac{1}{2}} - 5p^2P_{1\frac{1}{2}}$	$5p^2P_{\frac{1}{2}} - 5d^2D_{1\frac{1}{2}}$
In III	57185	61527	71273
Sn IV	69559	76077	95738
Sb V	81566	90554	120341
Te VI	93336	105151	144745
I VII	104960	119957	169059

of three lines and Hartley's Law, to fix up a fourth *i.e.* ν 154055 .

TABLE II

Doublets of I. VII.

$5p$	$^2P_{\frac{1}{2}}$		$^2P_{1\frac{1}{2}}$	
$5s\ ^2S_{\frac{1}{2}}$	104960	(5)	119957	(6)
$5d\ ^2D_{1\frac{1}{2}}$	169059	(4)	154055	(20)
$^2D_{2\frac{1}{2}}$			156294	(6)

Further support to the scheme presented in Table II is afforded by the fact that the two intervals 5p ($^2P_{\frac{1}{2}} - ^2P_{1\frac{1}{2}}$) and 5d ($^2D_{1\frac{1}{2}} - ^2D_{2\frac{1}{2}}$) obey the law of screening constants. The line ν154055 (20) is of abnormal intensity but is found to represent also the combination, $5p^3P_2 - 5d^3D_3$ in I VI.

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November 3, 1948.

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1. *Jour. de Phy. et le Rad.*, 1937, **8**, No. 9.

A NOTE ON CARP OVA AND THEIR HATCHING

IN the river Halda of Chittagong, East Bengal, millions of ova of *Catla catla* (Hamilton), *Labeo rohita* (Hamilton) and *Cirrhina mrigala* (Hamilton) are collected in various stages of development and are hatched in specially prepared hatchery pits excavated

on the banks of the river.[1] The larvæ thus obtained are nursed till these are transformed into fry and attained the age of 4-5 days. By this time the fry are sufficiently grown up to stand transportation and are exported in earthen vessels to long distances for cultural purposes. A large number of developing ova were collected during the spawning seasons of 1946, 1947 and 1948 and weighed with a fairly sensitive balance to ascertain the correlation between their weight and number. Several observations were made and it was found that on an average 7,520 ova weighed one lb. In the year 1947 as much as 100 lbs. and this year 113 lbs. of ova were collected by us. The collection was a mixture of eggs of the three major carps named above but with those of *Mrigala* dominating.

Incidentally it may be pointed out that Khan[2] found 1,85,854; 65,450 and 35,378 ova weighing one lb. in each case in gravid females of *L. rohita*, *C. mrigala* and *C. catla* respectively. The writer counted 13,920 ova of different sizes in the ovaries, 3·2 oz. in weight, of *Barbus* (*Lissochilus*) *hexagonolepis* McClelland, in the breeding season. Similarly in ovaries, weighing 2 oz., of the same species of *Barbus*, 8,724 ova were found. The ova while inside the ovary are closely surrounded by membranes but as soon as shed and fertilized, swell enormously by absorption of water. Thus egg[3,4,5] of *C. catla* increases from 2·0-2·2 mm. to 5·3-6·5 mm. in diameter, egg of *L. rohita* from 1·5 mm. to 4·5-6·0 mm. and of *C. mrigala* from 1·5 mm. to 3·0-4·0 mm., while the increase in diameter in *B.* (*Lissochilus*) *hexagonolepis* is not very appreciable. The increase in weight of the egg is, however, many times more than in diameter.

In the nursery pits larvæ of the major carps hatch out within 24 hours of fertilization of ova. These were collected a day after hatching and weighed. About 3,53,280 of them weighed one lb. On this basis, out of 94 lbs. of fertilized ova, only 2 lbs. (at that stage) of larvæ can be obtained, if the hatching percentage be cent per cent. In the departmental hatchery temporarily set up at the river Halda, out of 113 lbs. of ova (8,49,760 in number approximately,) 6,10,080 fry were obtained on the 4th day after hatching. The weight of these fry on the day was 4 lbs., i.e., approximately 1,52,520 of them were equal to one lb. The same number of specimens, i.e., 6,10,080 which weighed 4 lbs. on the 4th day, weighed only 1·8 lbs. a day after hatching. The hatching percentage in this case, on the basis of calculation on the 4th day, comes to about 72%.

"The local hatchers are under the impression that they get 75 per cent. and even 100 per cent. of the eggs hatched but as they get generally something like 1 oz. of larval fish to 75 oz. of eggs, their contention seems to be very doubtful," observed Mazumdar.[6] According to the information collected by the writer the spawn catchers usually get from 25 to 50% hatching by following their usual methods. They do not have very clear idea about the weight, number, etc., because they seldom count them and weigh them only after 4-5 days when actual sale begins.

Directorate of Fisheries, NAZIR AHMAD.
East Bengal, Comilla,
November 5, 1948.

1. Ahmad, Nazir (in press). 2. Khan, Hamid, *The Punjab Fisheries Manual*, 1945, 6. 3. Ahmad, Nazir, *Proc. Nat. Inst. Sci. India*, 1948, 23. 4. Khan, Hamid, *Bomb. Nat. Hist. Soc.*, 1934, 657-59. 5. Mookerjee, H. K., *Science and Culture*, 1944-45, 401. 6. Majumdar, C. H., *Ibid.*, 1940, 735.

PHOTO-ELECTRIC ESTIMATION OF SILICON IN STEELS

IN the course of our investigations on colorimetry and metallurgical analysis we had occasion to devote considerable attention to the estimation of silicon in steel by employing the molybdenum blue method. In the present note it is proposed to summarise the broad features of our observations which may be stated as follows:

(1) It would be highly advantageous to employ 35 m.l. of an oxidising solvent mixture, prepared by dissolving 6 to 7 grams of ammonium persulphate in 100 m.l. of 10 per cent. sulphuric acid, instead of 70 m.l. of 5 per cent. acid alone as recommended by Vaughan[1] for the initial treatment of the steel samples. This results in a saving of at least ten minutes in the time taken for dissolving the sample; further, the addition of $KMnO_4$ can be avoided.

(2) There seems to be no need to drive off the residual sulphurous acid. On the other hand, it is found that in the presence of adequate excess of this reagent the results obtained are very satisfactory and easily reproducible.

(3) Attempts to replace sulphurous acid by hydrogen peroxide in Vaughan's procedure (*loc. cit.*) showed that greater care is needed in this case since even a slight excess of hydrogen peroxide lowers the drum differences considerably. A reducing medium is distinctly more favourable than an oxidising one.

(4) Increasing the concentration of hydrochloric acid in the stannous chloride reagent has the effect of increasing its stability without exerting any adverse influence on the intensity or stability of the final blue colour.

(5) The concentration of sulphuric acid added at the second stage can be varied conveniently between 20 to 40 per cent.

(6) Waiting for fifteen minutes after the addition of stannous chloride has been found to be unnecessary in tropics where the prevailing laboratory temperature is considerably high. A saving of ten minutes could easily be effected at this stage. It has also been noted that the estimation must be completed within thirty minutes after the addition of stannous chloride, failing which the blue colour gradually begins to fade.

(7) After the initial treatment, the steel solutions can be preserved for a considerable number of days without any deterioration,

This comes in handy to check the concentration-drum difference graphs periodically by employing the stock solutions of standard steels instead of starting right from the beginning in each case.

Based on the observations recorded in this note a modified procedure has been evolved for the estimation of silicon in steel by adopting which, it has been possible to effect a saving of about twenty-five minutes for a single estimation. This has been applied to a large number of steels covering a wide range of variety and is being extended to some more. Full details giving further particulars will shortly be published elsewhere.

The authors' thanks are due to the management of the Tata Iron and Steel Co., Ltd., for permitting the publication of this note and to Dr. J. C. Ghosh and Mr. N. B. Sen, our present and former Chief Chemists, for their keen interest in the work.

G. V. L. N. Murty.
N. C. Sen.

Res. and Control Labs.,
The Tata Iron & Steel Co. Ltd.,
Jamshedpur,
November 9, 1948.

1. Vaughan, E. I., *The Institute of Chemistry Lecture on "Further Advances in the Use of the Spekker Photo-Electric Absorptiometer in Metallurgical Analysis,"* 1942, pp. 6, 7 and 8.

ASSIMILATION OF PHOSPHORUS DURING THE DECOMPOSITION OF PLANT MATERIALS

A small abstract on the subject was published by the writer in the *Proceedings of the Indian Science Congress*, 1936. Since then Sing Chen Chang[1] has studied the problem in some detail but he has not been able to arrive at any definite carbohydrate and phosphorus relationship giving "Phosphorus Factor" as compared to the "Nitrogen Factor". This is perhaps due to the difficulty in arriving at the figure for the microbial phosphorus synthesized from mineral phosphorus for want of suitable method to distinguish it from the organic phosphorus initially present in the plant tissue. Secondly plant tissues contain mineral phosphorus in varying amounts in addition to the organic phosphorus and since the phosphorus requirements of organisms are much smaller compared to nitrogen, it is possible that even the small amounts of mineral phosphorus that may be originally present may be sufficient to meet the requirements of the organisms.

The following results, while similar to those obtained by Sing Chen Chang, also serve to bring out the existence of a "Phosphorus Factor" governing the relationship of phosphorus and carbohydrates during the decomposition of plant materials.

Plant materials were decomposed in bottles which were incubated at 30° C. Total phosphorus was determined at stated intervals by ashing the material with magnesium nitrate and bringing it into solution according to A.O.A.C. method. Inorganic phosphorus was separated by extraction with 1 per cent. HCl-Alchohol mixture. The colorimetric method of Fiske and Subbarow[2] was used for the determination of phosphorus in the samples.

The data in Table I A indicate the synthesis of organic phosphorus during decomposition of wheat straw upto 28 days; with the increase in the period of decomposition organic phosphorus mineralizes as judged from the last column in Table I A.

Table I

Transformation of Phosphorus during the Decomposition of Wheat Straw and HCl-extracted wheat straw.

Days	% Loss of dry matter	% Total P	% Mineral P	% Organic P	Organic P % of Total P
A. (Wheat straw + N at the rate of 1% as ammonium sulphate)					
0	0·0	0·250	0·130	0·120	48·0
14	25·0	0·333	0·163	0·170	51·1
28	40·8	0·417	0·167	0·250	59·9
56	50·5	0·501	0·243	0·258	51·4
B. (HCl-extracted wheat straw + N at 1% as ammonium sulphate)					
0	0	0·128	..	0·128	100·0
14	5·1	0·129	..	0·140	100·0
28	10·9	0·144	0·020	0·124	86·1
56	25·2	0·172	0·038	0·134	78·4

Since HCl-Alchohol mixture as indicated by Collison[3] removes inorganic phosphorus, the results in Table I B represent changes in decomposition when the starting material contained only organically combined phosphorus. The results would suggest that mineralization of phosphorus is essential before any decomposition is possible and that organic phosphorus does not appear to be readily available.

Since the foregoing results do not clearly indicate the amount of mineral phosphorus immobilized during decomposition, cellulose in the form of filter-paper was decomposed as scheduled below; use of filter-paper eliminates the complications arising out of the use of plant tissues containing both organic and inorganic phosphorus.

Table II

Assimilation of mineral phosphorus during the decomposition of filter-paper

10 gm. of filter-paper was decomposed for 6 weeks in the presence of KH_2PO_4, 1% N as sulphate of ammonia and traces of minerals 5 c.c. of inoculum from a garden soil was added to each bottle.

Treatment	Cellulose decomposed	Inorganic P recovered	Inorganic P used up	Assimilation of P per 100 gm. Cellulose decomposed
2 mgm. P	1·05 gm.	nil	2·00 mgm.	0·1905 gm
4 ,, ,,	1·63 ,,	0·70 mgm.	3·30 ,,	0·2024 ,,
6 ,, ,,	2·05 ,,	2·08 ,,	3·92 ,,	0·1912

Figures in the last column of Table II suggest that "Phosphorus Factor" may be of the order of one-fifth that of the "Nitrogen Factor" (Richards and Norman)[4] assuming nitrogen factor to be unity for most plant materials. This figure agrees with that of Jenkins[5] who has observed in his studies on the biological oxidation of carbohydrate solutions that the proportion of phosphorus for efficient utilization of nitrogen lay between 0·12 and 0·31 parts per part of nitrogen. In other words, on an average, the phosphorus requirements of microflora are nearly one-fifth that of nitrogen. From the figures recorded by Sing Chen Chang on cellulose decomposed and the amount of inorganic phosphorus assimilated in 121 days at different levels of mineral phosphorus, the average phosphorus requirement of organisms for bringing about the decomposition of 100 gm. of cellulose works out to 0·26 gm.

It is thus reasonable to suppose that since the phosphorus requirements are nearly a fifth of their nitrogen requirements, the amounts of mineral phosphorus initially present in plant residues are thus quite enough for a satisfactory rot and that phosphorus therefore does not become a limiting factor for decomposition.

Further datailed experiments are in progress on this important problem.

Chemistry Section, J. G. Shrikhande.
Agricultural College.
Kanpur,
November 9, 1948.

1. *Soil Sci.*, 1939, **48**, 85; 1940, **49**, 197. 2. *J. Biol. Chem.*, 1925, **66**, 375. 3. *Ibid.*, 1912, **12**, 65. 4. *Biochem. J.*, 1931, **25**, 1769. 5. *Ibid.*, 1935, **29**, 116.

A NOTE ON "THERMOCHOR"

After Sugden's *Parachor* and Friends's *Rheochor* comes another property 'Thermochor' (Carvalho[1]) which may prove to be a useful tool in physico-chemical research although it is too early to judge its potentialities. The property is associated with molecular volume V_m of the substance at the boiling point and is defined by

$$\text{Thermochor} = [T] = [M/D]^{5/6}\, T_b^{1/4} = [V_m]^{5/6}\, T_b^{1/4}$$

where T_b denotes the boiling point of the liquid on the absolute scale at normal pressure. It is proposed to examine the above relationship in various types of compounds where V_m is either known (Kopp,[2] Lossen[3]) or can be calculated from temperature-density formula possessing sufficient degree of accuracy.[4] The following table contains the values of [T] for $-CH_2$ group in various types of compounds:—

Table I

Compounds		Min. and Max. limits in [T]	Average [T]
Nature	Number examined		
1 Hydrocarbons (aliphatic and satd.)	9	39·4–42·7	41·2
2 Hydrocarbons (aliphatic and satd.)	6	40·1–41·8	41·2
3 Hydrocarbons (aromatic)	5	38·9–42·1	41·0
4 Cycloparaffins* ..	5	34·6–39·0	34·9
5 Alcohols ..	8	35·8–40·7	39·7
6 Fatty acids ..	8	39·5–44·5	41·2
7 Esters (formates) ..	8	38·4–42·1	40·9
8 ,, (acetates) ..	8	40·3–42·8	41·4
9 Alkyl chlorides ..	5	38·7–42·3	39·8
10 ,, bromides ..	6	40·0–41·5	40·9
11 ,, iodides ..	8	39·8–43·5	41·5
12 Ethers ..	7	39·2–43·0	41·3
13 Nitriles ..	5	37·5–41·6	39·8
14 Thio-Compounds* ..	5	37·9–39·1	38·6
15 Amino Compounds* ..	3	35·3–38·5	37·3
16 Aldehydes* ..	4	36·1–37·2	36·7

From Table I it appears that the value of [T] is comparatively lower in compounds marked with an asterisk specially cycloparaffins. Further, by the usual method as adopted in the case of Parachor, the value of [T] for H_2 has been found to be 19·5 ($C_nH_{2n+2} - nCH_2$) from paraffins. From this result the atomic thermochors for various elements have been calculated and are given in Table II.

Table II

Elements :	H	C	F	Cl	Br	I	S	N (amines)	O (ethers)	O_2 (Esters)	P	Si	As	Sn
[T] :	9·8	21·8	16	48	61	84	62	22	20	43	46	41	55	49

It has also been observed that just like Parachor the values of [T] for isomeric substances of similar constitution are almost the same as may be seen from the following two examples :

Isomeric compounds	[T]
1 Butyl formate ..	251·0
2 Propyl acetate ..	251·3
3 Ethyl propionate ..	250·0
4 Methyl butyrate ..	249·0

Isomeric compounds	[T]
1 Amyl formate ..	292·6
2 Butyl acetate ..	292·5
3 Propyl propionate ..	290·5
4 Ethyl butyrate ..	290·5

Other compounds containing different types of linkages are being examined from this point of view and a detailed paper will appear elsewhere.

We are obliged to Mr. M. R. Nayar for helpful suggestions.

Chemical Laboratories, RAM GOPAL.
The University, T. N. SRIVASTAVA.
Lucknow,
November 21, 1948.

1. Carvalho, *Nature*, 1947, **160**, 370. 2. Kopp, *Annalen.*, 1855, **96**, 153, 303. 3. Lossen, *ibid.*, 1889, 254, 42 and others. 4. *International Critical Tables*, 1928, **3**, 27.

ON THE BIONOMICS OF THE FOWL TICK, *ARGAS PERSICUS*

LITTLE work has been done in India on the bionomics and life-history of the fowl tick, *Argas persicus* and there is a good bit of variation in the results obtained by different workers abroad [Sories (1922),[1] Newman (1924),[2] Salisbury (1938),[3] Rovida (1940)[4]] regarding the period of hatching of eggs and the survival of the larvæ in the absence of a host.

All observations both on the hatching of eggs and the survival of larvæ were made by me at room temperature, mainly during the months of July, August, September and October when the average temperature ranged from 82° to 97°F and the average percentage of humidity ranged from 73 to 83.

It has been generally observed that reproduction in this tick depends directly on the ingestion of food. I have never come across pairing or oviposition when the ticks were kept starved in tubes. Within a couple of days after these ticks, under varying periods of starvation, were allowed to feed on a fowl, the female started laying eggs in batches of 20-60.

The eggs are round and a little smaller in size than a pin-head. They are laid in irregularly shaped clusters and when fresh are of a bright fawn colour. The colour is a good index of age and gradually fades away from a bright fawn to pale-grey as the eggs grow older. After a couple of days of incubation the eggs become slightly flattened dorso-ventrally. Between the 3rd and 5th day a few dark spots (stumps) or tubercles appear towards the margin and these develop into appendages on the 5th or 6th day. Most of the eggs hatched after 7 days although the range of incubation period was from 6 to 9 days.

For the first two days after hatching the larvæ remain sluggish; later on they become very active as if in search of food (host). In the beginning they are quite plump, bulging out dorsally, till about the twentieth day when they become weaker and thinner. By this time the body juices have dried up and ultimately the larvæ become thin and leathery with well-defined margin and disinclined to crawl about. Some of the freshly hatched larvæ were kept under starvation when moulting took place as was evident from the cast off skins found in the tubes. Regarding the period of survival of the larvæ my observations reveal that a period from 56 to 113 days under varying climatic conditions is possible.

Acknowledgement: I am grateful to Dr. B. C. Basu, Entomologist, Indian Veterinary Research Institute, Izatnagar, for allowing me access to his private library and to Dr. M. B. Lal, Reader in Zoology, Lucknow University, for his guidance, helpful suggestions and criticism in the preparation of this paper.

Animal Husbandry Dept., S. H. QURESHI.
United Provinces,
Lucknow,
November 25, 1948.

1. Sories, A. S. *Rev. App. Entom.*, 1922, **10**. 2. Newman, L. J., *J. Dept. Agric.*, W. Australia, 2nd ser., 1924, No. 1. 3. Salisbury, S., *J. Rhod. Agric.*, 1938, **35**, No. 1. 4. Rovida, R. J., *Inst. Parasit., Enferm*, I, 1940, fasc. 6.

PREPARATION OF AMYLOSE BY THYMOL PRECIPITATION METHOD

A number of methods have been suggested from time to time for the preparation of amylose component of starch. The more recent one is that of Haworth, *et al.*[1] and the principle of the method is that amylose can be precipitated as a water insoluble complex by thymol. This method is stated to be free from certain difficulties encountered in the earlier methods. We followed this method and found that the purity of the sample was not as good as the one prepared by Hassid's method, i.e., by precipitation with Methanol.[2] By a slight modification of Haworth's method described in this note, we obtained amylose of purity comparable to that prepared by Hassid's method.

The effect of temperature and duration of heating on the extraction of amylose from starch without rupturing the granules was studied and the optimum conditions for the maximum extraction of amylose were established.

Starch was dispersed in water and poured into water at 80° C. (to make a 1% solution) and kept at that temperature for 1½ hours, with frequent stirring. The solution was allowed to cool down to room temperature and centrifuged. To the clear water extract of the amylose thus obtained, are immediately added sodium chloride to make a 0·1% solution and then thymol to saturation. The precipitation of thymol amylose complex starts almost immediately and is complete in about 24 hours. The precipitate was centrifuged off, washed with thymol water, absolute alcohol and ether. The yield and purity of the amyloses prepared as above and by Hassid's method are showing the following table. The

Method followed	Blue value	Yield %
Present modified method ..	252	13-15
Hassid's method ..	250	10-11

purity of the amylose samples are expressed in terms of blue units, determined according

to the method of Hassid and McCready[2] using a Klett-Summerson Photoelectric Colorimeter with the red K_{66} filter. Sweet potato starch was used for preparing the amylose samples.

Similar results were obtained with amylose samples prepared from potato and corn starches.

S. LAKSHMANAN.
Dept. of Biochemistry, J. SRI RAM.
Indian Institute of Science, K. V. GIRI.
Bangalore,
November 30, 1948.

1. Haworth. Peat and Sagrott, *Nature.*, 1947, **15**[7], 19.
2. McCready and Hassid., *Jour. Am. Chem. Soc.*, 1943, **65**, 1154.

"VARAGU", *PASUPALUM SCROBICULATUM* (LINN.)

THE millet known as "Varagu" (Tamil), Kodra (Hindi), *Pasupalum Scrobiculatum* (Linn.) is extensively used as a staple food by poorer classes in all parts of India. In 1946, when rice was rationed, the Government of Madras compulsorily required part of the rice to be replaced by varagu by those who were accustomed to use millets as food. Various complaints were received that some varieties of Varagu consumed were producing poisonous symptoms. On the recommendation of one of us (K. V. S.) a Committee consisting of the Surgeon-General, Director of Public Health, Director, King Institute, the Govt. Analyst, and the Millet Specialist was constituted and they recommended that Government should undertake, through the Government Analyst, an investigation of Varagu Poisoning.

Some samples were found to be toxic to dogs. Stas Otto method was negative showing that the poison was not an alkaloid. But as a number of samples were found to be undoubtedly poisonous to dogs a systematic investigation was attempted. It was found that the fat residue obtained from extracts with petroleum ether (B.P. 60—95° C.) or chloroform was definitely toxic. The fat gave the following figures: (average)

Melting point 42°C.
Refractive Index (60°C.) 1·4650
Iodine Value 93·6
Saponification Value 107·7

of the fat contained in 50 grams of the millet 1·5 grams when fed to dogs, developed tremours within two hours. The dogs soon lost their power of movement and died within 24 hours. Attempts to feed monkeys with the fat failed as they refused to take the food Subsequently we found that when the fat was injected subcutaneously into dogs the symptoms described above were observed. We were able to reproduce the symptoms in monkeys by intramuscular injection. Crows were found to be extremely susceptible to both oral ingestion and intramuscular injection. After ten minutes of taking the food they vomit the food, the pupils become fixed, they droop their heads, soon lose power of moving and are dead in 24 hours. The fat is stable to heat but the toxin in the fat seems to be easily destroyed on heating with dilute alkali and acid. It could not be an alkaloid as it is not taken up in acid solution or a glucoside as it is not taken up by water or 90% alcohol. The poison seems to be adsorbed chromatographically on silica column and further experiments are in progress.

These facts seem not to have been recorded in literature so far as we are aware, *viz.*, of a fat derived from a millet having been found to contain a substance which is poisonous to man and animals. Our findings of the effects by intramuscular injection on dogs, monkeys and especially on crows should provide a new method of approach for studying the presence of poisonous elements in fats and of estimating the lethal doses.

A simple colour test based on the reaction of concentrated sulphuric acid on the fat is being worked out to distinguish the poisonous variety of Varagu from the non-poisonous variety of Varagu.

K. V. SUNDARAM AYYAR.
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Government Analyst Laboratory,
Guindy, Madras,
December 1, 1948.

DIRECTOR-GENERAL OF UNESCO

DR. JAIME TORRES BODET, Foreign Minister of Mexico, has been elected the new Director-General of the United Nations Educational, Scientific and Cultural Organisation.

Dr. Bodet, born in Mexico on 17 April 1902, received his education in that country. An eminent author, and former Minister of Education in Mexico, he has written three volumes of poetry, six novels, and many books on education. For his outstanding work in the educational field, the University of Mexico and the University of Southern California conferred on him the honorary title of Doctor in Letters. He is also an active member of the Mexican Academy of Languages. While with the Ministry of Education, Dr. Bodet organised a system of public libraries throughout Mexico, and assisted in the translation of the classics which were published by the Mexican Government. He was Professor of French Literature in the Department of Philosophy and Letters in Mexico from 1924 to 1928.

He entered the Foreign Service in 1929 and held diplomatic positions in Spain, Holland, Belgium and France.

In 1943 he was appointed Minister of Education, at which time he initiated the world famous Mexican campaign against illiteracy. In November 1945 he headed the Mexican delegation to London and attended the Conference which created Unesco. He was one of the original signers of the Unesco Charter.

He has been Foreign Minister of Mexico since December 1946, and in that capacity led the Mexican delegation to the Inter-American Conference for the Maintenance of Peace. He was also head of the Mexican delegation to the Second General Assembly of the United Nations, where he was elected Vice-President.

Dr. Bodet will assume his duties as Director-General of Unesco in Paris at the beginning of 1949.

REVIEWS

Natural Philosophy through the Eighteenth Century and Allied Topics. Edited by Allan Ferguson. (Taylor & Francis Ltd., London E.C. 4), 1948. Pp. i-vii, 1-164. Price 15 *sh.*

The volume under review has been issued as Commemoration Number to mark the 150th Anniversary of the foundation of the Philosophical Magazine and forms a welcome addition to the growing literature on the History of Science.

The opening chapter by Ferguson and Ferguson contains a vivid account of the beginnings of the Magazine in 1798 and gives many interesting details about the personalities of Alexander Tilloch, Richard Taylor and Dr. William Francis who between 1798 and 1904 did yeoman service in the matter of editing and publicising the Magazine. In a rapid survey of its history over a long period, the authors convince us that the Philosophical Magazine has had its share of important publications in the scientific field, *e.g.*, by Rowland, Hamilton, Lord Kelvin, Michelson, Morley, J. J. Thomson, Rutherford, Bohr, Mosley, Chadwick and Millikan, to mention only a few.

The history and progress of Natural Philosophy in the 18th century is dealt with under four headings in the next four chapters : Astronomy by Sir H. Spencer-Jones, Physics by Herbert Dingle, Chemistry by J. R. Partington, and Mathematics by J. F. Scott. The authors in the respective fields must be congratulated for the remarkable sense of perspective and proportion which they display in dealing with the necessarily vast amount of data on the subjects due to the immensely detailed development of scientific thought in the 18th century.

The impression one gets of Natural Philosophy in the 18th century on reading through these 80 pages is of a period in which the great mathematical physicists such as Clairut, D'Alembert, Lagrange, Laplace and others vie on the one hand with the astronomers such as Flamsteed, Halley and Herschel, and on the other, with the physicists and chemists such as Rumford, Coulomb, Priestly and Lavosier in wresting secrets from the womb of Nature. The galaxy of great names too numerous to be mentioned in full pass and many times repass delightfully before our vision.

The rest of the volume is devoted to a consideration of the status of topics allied to Natural Philosophy. In a chapter devoted to Engineering and Invention, Captain Edgar C. Smith has given an excellent picture of the manner in which the rising tide of scientific thought in the century reacted upon industry in a very favourable manner, enabling men like James Watt, Richard Arkwright and Hargreaves to revolutionise manufacture and industry by their many beneficial inventions.

In the chapter devoted to Scientific Instruments, Robert Whipple presents many a great name in the History of Science of that period in the novel role of instrument designers and instrument makers, which it will be realised remains as important a branch of science today as it was then. We meet here Huygens inventing a pendulum, Hooke devising the anchor escapement, Fareinheit perfecting the first modern thermometer, De Luc making a barometer, Ramsden shaping an eye-piece, Martin at work on the microscope, von Kleist busy with the Leyden Jar, Coulomb constructing his torsion balance and Volta assembling the first battery in the history of electricity.

The last three chapters provide a good deal of interest to the earnest student of the History of the Science not unmixed perhaps with a little amusement also. Dr. Doughlas McKie takes us to the very scene of the struggles of the Scientific Periodical, in attaining to a position of independence when they had no longer any necessity to provide "entertainment" for the benefit of the leisured amateurs in return for their patronage. The same author has made an able review of the increasingly useful role of Scientific Societies in the century.

The last chapter by Sherwood Taylor on the Teaching of Science in the 18th century is of absorbing interest, in showing clearly that eminence in science is largely then as now a matter of personal taste and intense application, nurture and opportunities of course playing their due part.

We have no hesitation in saying that judged even by the standards of the Philosophical Magazine the volume under notice attains to a degree of all-round excellence, well worth maintaining.

H. R.

General Biology. By James Watt Mavor. (Macmillan Company, New York.) 3rd Edition. 1937. Pp. 986. Price. 27*sh.* 6d.

Dr. Mavor has brought out a third edition of his "General Biology," in which some of the chapters have been revised, and additional material presented on the structure of matter and organic compounds. This is a book attempting to present a general picture of the major branches of Biology, for the benefit of the elementary student, and for those in charge of such instruction. The science of Biology is such a vast one, and its frontiers are expanding at such rapid pace, that it is almost impossible to give even a general picture of the whole subject in the compass of a single volume. The author has obviously failed to achieve the impossible, and the book betrays a series of compromises, between the requirements of the School and the College, between the teacher's freedom and the student's need, between type method and the general discussion method, between morphology and physiology, between comprehensiveness and concern for fundamentals, between bulkiness and primer-like treatment.

The book is divided into six parts. The first part deals with a general account of the nature of life, and is intended to serve as a general

foundation for the study of material presented in later chapters. This part is well written. Chapters 4, 5, 6 and 7 of Part I, entitled respectively, the Cell; chemical elements and inorganic compounds; organic compounds, colloidal systems and membranes; and Cell Physiology, attempt to give within a fairly brief compass a foundation in chemistry and physiology which is indispensable for understanding the new orientation that has come about in biological studies in recent times. It is very unusual to find these topics discussed in biological books in a manner understandable to the beginner. It is high time that every teacher of biology insisted on his students getting a grasp of the material of these chapters.

The second part deals with plant life and briefly considers examples from the main groups of the plant kingdom, beginning with the blue-green algæ and ending with the flowering plants. The treatment of such a large topic in the space of about 160 pages, including illustrations, is necessarily very brief. It is very satisfactory to note that in dealing with the morphology of representative types, the evolutionary aspect is kept in mind. This certainly helps the student to get a picture of the plant kingdom as a whole, and impresses on him the evolutionary connection between apparently isolated groups of plants.

A similar plan as in Part II is followed in Part III, entitled "Invertebrates". Again, sufficient justice is not done to the vastness of the subject.

Part IV dealing with vertebrate anatomy and physiology based on the frog and man errs in the opposite direction. These two parts are apt to give a wrong impression to the student that vertebrates alone matter in the scheme of animal life, and that what is true of the frog and man is also true of all animals. This imbalance is the inevitable result of the attempt to effect a compromise between the system of treatment based on full and detailed description of particular types and that which avoids types and concentrates on general description.

The fifth part dealing with the development and heredity in plants and animals is treated in a most elementary manner. The science of heredity is one of the most important branches of biology, and the attention it deserves has not been paid in this section.

The sixth and the last part dealing with the organic world and its evolution is well written and should be stimulating to the student who has already taken his first lessons in biology.

After going through the book one cannot help the feeling that the book is somewhat loosely knit. The author says that "the order in which material is presented has been chosen both with regard to the logical development of the subject and to close correlation between laboratory and classroom work. Nevertheless this order need not been strictly adhered to as *the parts of the book are to a considerable extent independent* (italics mine). To give latitude to the teacher and make possible variations in the course from year to year in a number of cases alternate types have been discussed and sections have been written so that they may be omitted or included without serious loss of continuity". This is an admission of the essential weakness of the book. While aiming at this abstruse logical development he has introduced discontinuity in the grosser aspects of the book, which in a book professedly meant for the elementary student is an unfortunate drawback.

Notwithstanding the weaknesses pointed out above, the book contains a great deal of material, and some of the chapters are indeed very readable. The printing, illustrations and general get-up are very good. A. A.

Biology of Pathogenic Fungi. Edited by W. J. Nicherson. (Waltham, Mass., U.S.A., Chronica Botanica Co.; Calcutta, Bombay and Madras: MacMillan & Co. Ltd.), 1947. Pp. xx + 236. Price 5·00 dollars.

The book brings together results of fundamental investigations on different phases of the biology of fungi pathogenic to man which are essential for a thorough programme aimed at the prevention, prophylaxis and treatment of mycotic diseases. It provides an interesting and illuminating reading and has been presented in a clear and simple manner. The book is divided into twelve chapters and each chapter gives an up-to-date review of the subject concerned. The restraining influence of skin and dead epidermal structures on the growth of dermatophytes and the changes in such resistance occasioned by attrition in nutrition and the concomitant hygienic levels have been dealt with. Atttention is also drawn to the possible role of zinc present in highest concentrations in the parts of the body affected by dermatophytes in the defence against fungus invasion, the importance of studies on the enzyme elaborative abilities of the fungi concerned and the negative correlation between the nutritional requirements of a fungus and its pathogenicity obtained as result of investigations on the nutrition, metabolism and chemical constituents. In addition to the biology of *Torulopsidoideæ*, physiology, history, distribution and histopathology, etc., of *Chromoblastomycosis* have been fully dealt with. Mycological aspects of the disease have particularly found an adequate presentation. Nomenclature, nutritional requirements and cultural characteristics of *Pityrosporum ovale* the organism found in *Pityriasis* are also discussed. High incidence of *Coccidioidomycosis* has been correlated with the distribution of rodents in the endemic areas indicating an animal reservoir of the disease.

Action of sulphonamides on the pathogenic fungi has been dealt with at some length. The generally accepted "Paraminobenzoic acid theory" is explained and the fungistatic action of sulphonamides has been fully discussed. Although considerable success has been reported in case of certain diseases, need for further clinical experiments regarding sulphonamide therapy has been stressed. The book ends with an informative chapter on the respiration and fermentation of pathogenic fungi. Of the many fungi responsible for diseases of man, only a few have been investigated from the point of view of their oxidative activities and the chapter brings together available knowledge on the subject. Though

respiration of cells in general follows a basic pattern, it is well known that even related species carry out apparently identical oxidations by different catalytic mechanisms and pathways. The author compares the present knowledge of the oxidative and fermentation processes of pathogenic fungi with the more extensive information available for non-pathogenic forms. The book in addition to compiling together modern data on different aspects of the biology of fungi pathogenic to man, brings out the lacunæ existing in our knowledge of taxonomy, distribution, metabolism and therapeautic measures.

The different subjects have been dealt with by authorities on the particular items and the book in the present form of our knowledge leaves nothing to be desired and should be welcome by students of human mycopathology. Further, the book shows the importance of biological studies and other rational approaches to a knowledge of mycotic diseases, particularly in a country like India where, in spite of indifference of medical men and the consequent imperfect surveys, fungus affections have been known to constitute as high as 20 per cent. of the common diseases in contrast to America where fungus affections are reported to be 3·4 per cent. or even less.

R. S. VASUDEVA.

Field Guide to Birds of the West Indies. By James Bond. ix + 257, 1 coloured plate, 211 line drawings. Maps inside cover, front and back. Size 7½"×5". (The Macmillan Co.), New York, 1947. Price $ 3·75.

This little book is designed largely on the lines of Roger Tory Peterson's "Field Guide to the Birds" whose first appearance in 1934 literally took the bird watching public of the United States by storm.

"Its primary purpose", the author tells us, "is to enable the reader to identify in the field the various birds known to inhabit the West Indies", West Indies here meaning the Bahamas and the Greater and Lesser Antilles.

The descriptions giving local names, size, colouration, habits, nesting and range are usefully compressed, and in nearly all cases a well executed pen-and-ink sketch of the bird accompanies it, which should provide additional facility in identification. The arrangement of orders and families followed is mainly that of Peter's 'Checklist of the Birds of the World'.

A full index of local names at the end of the book is a useful innovation, particularly since the reader is advised to take with him an intelligent woodsman on his bird watching trips who will apparently be familiar with the birds by their local names and know where to find them.

In the descriptions, emphasis is laid on call notes and songs since in the dense forest many birds are more likely to be heard than seen. We doubt, however, if calls as printed in a book can convey much to the hearer who is not already familiar with them by ear. The difficulty of rendering bird calls intelligibly in print is one that many ingeniously devised systems of transliteration and notation have so far failed to overcome.

Some instructions are contained in the Introduction for the benefit of travellers regarding how to reach the remoter birdy spots of the islands etc. Among these the naive injunction that "Natives should at all times be treated with the greatest respect, but never with intimacy ...." is reminiscent of the exotic precepts contained in the booklet of instructions with which American soldiers during the war were armed by their thoughtful Government for correct department with the natives of India.

The chapter ends with a plea for the creation of sanctuaries for the preservation of West Indies birds, many of which have become very rare and are in grave danger of extinction.

The book should serve its primary purpose admirably, and may be taken as a model of the type of bird book that we in this country want for each province and unit of the Indian Union.

S. A.

International Rules of Botanical Nomenclature. Compiled from various sources by W. H. Camp, H. W. Rickett & C. A. Weatherby. (Publishers: Waltham, Mass.: The Chronica Botanica Co., Calcutta, Bombay and Madras: Macmillan & Co. Ltd.), 1948. Pp. 120. Price $ 3·50.

The Chronica Botanica Co. has done an important service to Systematic Botany by publishing the International Rules of Botanical Nomenclature, as preparations for the holding of the next International Botanical Congress in the near future are actively being made. As copies of the last (3rd) official edition (1935) of the Rules were no more available, and as the Amsterdam Congress in 1935 had made additional changes in the Rules published earlier in that year, it was necessary that these should be made easily available to workers in Systematic Botany, many of whom were not likely to know them. This purpose has been served by the present publication, which is a careful compilation based on authentic materials and includes the official text of the Rules as amended at Amsterdam, together with the draft proposals submitted to the congress on matters included in several appendices, which have not yet been adopted officially. The authors are careful to point out that the present text, although taken from authentic sources, is in no way to be considered official. The format and get up of the volume are similar to that of the last official edition. The text is *only* in English instead of in English, French and German.

In view of the fact that the International Rules of Nomenclature are not generally known to the younger Indian Botanists and also to some seniors, we give below a comparative statement of the contents of this volume and the last (1935) official edition. In the main body of the rules only a few minor typographical errors which came to the notice of the compilers have been corrected.

Appendix I includes certain recommendations regarding the naming of fossil plants

made at the section of Palæobotany of the Congress at Amsterdam in 1935.

Appendix II contains a list of "Nomina Familiarum Conservanda" proposed by J. Lanjoux and T. A. Sprague, *not* adopted by the congress. This was not printed in the last edition.

Appendix III "Nomina Generica Conservanda" has been prepared in a different form from that of the 3rd (1935) edition of the Rules. Whereas in the 3rd edition, names adopted for conservation were printed separately from the proposals for conservation by various persons which were included in a supplement "Nomina Generica Conservanda proposita" the present compilation has combined these two lists indicating by suitable means the names definitely adopted for conservation by the Congress. The provision of an index to this part facilitates consultation. We feel, however, that it would have been better to have kept the two lists separate.

No proposals for Appendix IV "Nomina Ambigua", Appendix V "Nomina Confusa" and Appendix VI "Representative Botanical Institutions recognized under Act 36" having been received these appear as titles only. Appendix VII "Nomenclature of garden plants" by A. B. Rendle and a list of "Standard-species of Linnaean Generic Names of Phanerogams" as proposed by A. S. Hitchcock and M. L. Green, have been printed as in the official edition.

Altogether the compilation is a very useful one for working systematists and we recommend that every college and University library in India should obtain a copy.

S. P. A.

The Skin Diseases—A Manual for Practitioners and Students. By James Marshall, Consulting Dermatologist, Central Middlesex County Hospital, etc., etc. (Macmillan & Co. Ltd., London), 1948. Pp. x + 363. Price 30*sh.* Net.

Chapters I and II are devoted to the description of Anatomy and Physiology and the pathological changes met with in skin diseases in general. There is a chapter on syptomatology and chapter on the procedure of examination of skin diseases and the method to arrive at diagnosis. Diagrammatic sketches are given for the distribution of lesions in different types of diseases. Principles of treatment of skin diseases with a few useful recipes are discussed in Chapter V. The author has exhaustively classified the skin diseases on ætiological basis, *viz.*, Congenital abnormalities, physical agents such as heat, cold. X-ray, radium, etc., infectious fevers, pyogenic infection, syphilis, tubercle, leprosy, viruses, animal parasites like scabies, bacillary diseases like anthrax, etc., various kinds of epidermophytes, lesions of obscure ætiology like psoriasis, pityriasis, etc., diseases of toxic and allergic origin such as Eczema, erythema, urticaria, etc., drug eruptions, neurodermitis, pigmentary disturbances and various other causes. He has included a chapter on psychological aspects of skin diseases. It is not unusual for one to meet with patients who attribute their skin trouble to a previous nervous strain of shock or some kind of emotional disturbance. During the last war a number of cases of skin trouble were reported from among the prisoners of war. It may be possible that those cases were partly psychological and partly due to causes environmental and nutritional, because some of those cases recovered without further treatment when those persons were restored to normal life. In this small volume the author has given detailed discriptions of symptoms and treatment up to date. The book is copiously illustrated and a number of coloured plates are added to make a difficult and complicated subject very instructive. This manual should amply fulfil the authors purpose.

K. P. Menon.

The Advancement of Science, Vol. V. (Published by the British Association for the advancement of Science, Burlington House, London, W.I.), 1948.

The present number contains a large number of articles presented before the meeting of the British Association in Dundee in 1947. A wide variety of subjects have been discussed and reported. They range from subjects on "Mathematics", Insecticides, Human factor in Industry and finally end with a paper before the physics section on "Location of Thunderstorms by Radio".

A general survey reveals that, a large number of papers have been read before the various sections such as chemistry, physiology, agriculture, social and international relations of science and physics and discussions reported. It is encouraging to find in these articles a clear, practical and realistic approach to many of the applied problems in Agriculture and Social Sciences.

Discussing the Human factors in Industry under the Presidentship of Sir Henry Tizzard, F.R.S., the report records an interesting note on working conditions by Prof. Laue and human relations by Dr. Tredgold.

The problem of environmental conditions in Industrial worker and the method of helping to solve it on the preventive side by the Medical Officer-in-charge are made clear. Attention is pointedly drawn to the human wastage from disease and accident being maximum in miners. The important role played by engineers in lay-out and proper design to eliminate monotony and accidents. It is felt that to eliminate bad group morale, the industrial worker must be approached individually and taught simple methods of increasing and improving work. In the long run, better methods of honest co-operation are needed, and a large use of the present findings to future planning will help to solve the problem of the industrial worker.

The other useful articles are written with a view to enable even the layman to appreciate the findings of applied research in agriculture and industry. By these frequent meetings, discussions and records in the various fields of

science, the British Association, one of the oldest bodies in promoting the advance of science is performing a work which deserves praise from all quarters. The present number of the Journal, fully endorses the pioneering efforts of the Association in the advancement of science in all its branches. The journal serves as a happy balance between theory and practice of science which we so sorely need to-day.

T. N. R.

Cytogenetics and Plant Breeding. By S. N. Chandrasekharan, and S. V. Parthasarathy. (Publishers: P. Varadachary & Co., Madras. Pp. 589. Price Rs. 12-8-0.)

Genetics as applied to agriculture, is comparatively young, and plant breeding which about fifty years ago, was merely a toy and a hobby in the hands of a few rich and those interested, has today assumed the status of what is commonly called an exact Science. And in the present times no plant-breeder can be successful in his work unless he has a sound basic knowledge of the fundamentals of cognate sciences like, cytology, taxonomy and statistics. The chromosome theory of heredity is now an established fact, and many a genetical phenomenon, which formerly defied explanation, can now be interpreted on the basis of chromosomal structure, morphology and behaviour. As a natural corollary, while the plant-breeder of olden times achieved results through observations, which were necessarily long drawn out for the reason that they were neither scientific nor based on an understanding of the fundamentals of the mechanism of heredity, his present-day counterpart is able to synthesize new species almost at will incorporating therein, the desired characters, like increased yield, resistance to fungal or virus attack, earliness of flowering and the like. Much work in this direction has been done and useful results achieved in U.S.A., U.S.S.R., Sweden, England and until the outbreak of the war, Japan. The evolution through breeding, of different varieties of wheat, maize, apples, strawberry, etc., is known to almost everybody.

While we all know so much about work done, and success achieved elsewhere, little or next to nothing has been known even to us, let alone the outside world, about the work done in our own country. If, for nothing else, the authors of the book under review have to be congratulated for the care with which they have unearthed and laid before the student of Genetics, the bulk of the work and the data that lay buried, in agricultural journals and inaccessible departmental bulletins. The achievements of our countrymen in the field of plant breeding and genetics, may compare very favourably with those of other countries, when due allowance is made for the fact that, having been under the yoke of foreign domination, full-hearted encouragement has not been forthcoming for the free display of our Natural talents; nor was there much anxiety on the part of the alien rulers to build up on true foundations, those nation-building departments, like Education and Agriculture, whose proper set up and functioning would have meant all the difference between poverty and prosperity in the country. If in spite of these handicaps, so much has been accomplished, it is a matter to be proud of and even made much of. Sir T. S. Venkatraman's work, on the sugarcane made India self-sufficient in sugar; less spectacular, but no less important has been the work done by our men in respect of rice and millets.

The results of and the data incidental to these, have not been incorporated in any textbooks so far, such that they could be used in colleges, for teaching purposes. We have always relied upon Mendel's peas and other foreign examples to clarify genetical principles. And now for the first time, thanks to the authors of the book, it will be possible to illustrate the principles of heredity with examples taken from the researches made in our country.

The general principles of Genetics have been well enunciated and explained, with the aid of suitable examples, and diagrams taken principally from the works of various Research Divisions. Details have been given of pure line selection, and clonal selection, as practised in the Coimbatore Research Station, and a list of new rice and millet strains so evolved by the Madras Agricultural Department, has been catalogued.

In the evolution of new and improved varieties, the part played by hybridisation, accompanied or unaccompanied by chromosome duplication, has been duly emphasised. Results achieved by this means in Rice, Sugar cane, Cotton, &c., have been justifiably elaborated. Polyploidy and its artificial induction have received ample attention at the hands of the authors.

As plant-breeding is now a highly developed science, it cannot achieve its purpose, unless field experiments are very carefully designed, and the data statistically analysed. The authors have, therefore, done well in giving due prominence to statistics in relation to plant breeding. Copious details have been given of field plot technique and the appendices at the end of the book include gene symbols for paddy, cholam and cotton, and chromosome numbers of some of the more important Indian species of Angiosperms. It is not clear on what basis the list has been drawn up. It does not seem to be confined to economically important plants, though the bulk of the list is comprised of these. It would be worth the while of the authors in the next edition of the book to draw up a fairly complete list of chromosome numbers of all Indian species, wild and cultivated, with proper references. As it is, the list is scrappy with several important omissions, like palms, Aizoacea, and several other Angiospermic families.

A very useful glossary has also been appended. Though the book is one on plant breeding, a short chapter on human genetics would not have been out of place. It might have served to indicate how heredity in man has to be studied by methods which are different from those used for plants. As people are never bred for experimental pur-

poses, only inferences can be drawn from data collected from pedigrees. Interrelationships in plants that could have been obtained with certainty from pre-arranged experiments have only to be inferred by actuarial methods, in the case of human heredity.

Though the fundamental principles are the same in both, the plant-breeder should know, how the problems connected with human Genetics, should be approached and tackled as distinct from those of plants.

On the whole, the book should be welcomed with open arms, by all students of genetics, especially in this country. It is the first of its kind and the authors deserve the gratitude and congratulations of the Scientific World of India for having collected and placed before them in textbook form a mass of data which otherwise would have remained, scattered, and unco-ordinated and consequently useless. The book should find a place not only in all the libraries but also in the hands of every student who studies Botany either in its academic form as in Science Colleges, or in its applied form as in Agricultural College.

T. S. RAGHAVAN.

MARVELS OF FISH LIFE*

TO Dr. Schultz, the senior author of this work, fishes are the most fascinating form of animal life in the world. He has studied fishes in all continents, in lakes, rivers and seas, and in the atom-bombed atolls of Bikini. As the Curator of fishes of the Smithsonian Institution, the subject is to him both a vocation and a hobby. He tells us that his interests in fishes began from his boyhood but soon developed into a serious pursuit. "And the more I learn about fishes, the more I marvel at their variety and the colour and drama and odd quirks and excitement of their ways". His objects in writing this book is to share with others who are not ichthyologists, at least a little of the enjoyment which he and his colleagues get out of knowing the bizarre, astonishing and manifold ways of their favourite animals. The work is addressed to the general reader and not to the specialist, but the non-technical language and the narrative style giving information in the form of personal adventures and anecdotes do not in any way affect the accuracy of observations. In fact, there is a great deal of natural history that is new in this work even for the specialist who has spent most of his time studying fishes in the laboratory.

The opening section deals with the problem of migration in fishes with an account of the life-history of the European freshwater eel and the epic journey it makes to the Sargasso Sea to spawn, all made known to science by the classical researches of the late Johan Schmidt, the Danish Biologist and Physiologist. Unlike the eel that travel to the ocean to spawn there is the salmon which have the strongest homing instinct to come back for breeding to the freshwater streams where they hatched out and spent the early stages of their life-history. These are two extreme cases of migration but there are countless others where a definite migratory journey either for feeding or for reproducing the kind is performed with un-erring instinct. We are next told of the means of locomotion in fishes, of the fishes that jump, glide, fly, walk, skip and burrow. Many of the burrowers can, by hibernation or aestivation, tide over unfavourable conditions of the surroundings caused by extreme cold or by heat and disiccation. In the latter category are found some of the most interesting fishes of the world. for, they herald the lung breathing habits of the more advanced vertebrates The authors discuss the habits of the lung fishes, *Protopterus*, *Lepidosiren* and *Neoceratodus*. Under "Fishes dangerous to man" we read of the sting ray and a few of the less poisonous fishes, followed by the *piranha* of the Amazon, one of the most bloodthirsty fishes of the world, attacking man and beast without provocation, and vicious out of all proportion to its size, so much so that writers of detective fiction have not hesitated to employ it as an instrument of murder. The man-eating sharks and the large tropical *barracuda* get their due share of attention as enemies to man as also the swordfish which used to be so much dreaded in the days of wooden ships. The *Candiru*, the only vertebrate parasite of man is not so well known; this tiny South American catfish enter the sex organs of human beings while bathing or swimming in water and cause unbearable pain and often prove fatal to the unfortunate hosts. Among the poisionous category are many like the *pufer* whose flesh is definitely known to be poisonous; others less dangerous but none the less best avoided include *Ruvettus pretiosus* the "purgative fish". It is reassuring to hear, however, that not all fish now known as poisonous need be so, for, we are told that the fish that sustained a sailor adrift on a raft for several weeks after he was torpedoed in the high seas during the war happened to be the file-fish usually considered poisonous!

Feeding habits, association with other animals and fighting qualities are briefly discussed in the succeeding sections. We are told of *Dermogenys* and *Betta* which have been most assiduously bred and cultivated for centuries in Siam. The matched combats arranged between male *Betta*, one of the most handsome fishes even in its wild state, provide much amusement to the Siamese. On good authority we have it that there is nothing cruel about fighting *Betta*. "The rankest sentimentalist need waste no sympathy on the fighting fish-its physical discomfort is negligible, its recovery from its minor injuries is complete, and it seems to derive great satisfaction from its particular form of sport. So does the human onlooker".

* *The Ways of Fishes*. By Leonard P. Schultz and Edith M. Stern. (D. Van Nostrand, New York, and Macmillan, London), 1948. Pp. 12 + 1-264. 80 Text illustrations, Price $ 4·00 or 22 *sh.* net.

Production of light and electricity by fishes has always excited popular imagination but it is only recently that the physiology of these phenomena has been diligently pursued and, as yet, we know so little. An average sized individual of *Electrophorus electricus*, the electric eel of South American rivers, can produce discharges of about 550 volts; investigators have drawn from an eel almost 600 volts and about 1,000 watts. We are, at present, not in a position to utilize this tremendous output of electrical energy because this impulse is passed and gone in about two one thousands of a second. There are many fishes that light up their surroundings in the dark abysses of the ocean but only one is known which can glow and sing; this one, *Porichthys*, found on the Western Pacific coasts shows rows of shining buttons when disturbed, accompanied, in the male, by a humming sound. Sense of hearing and sight are also discussed. Fishes have no external ear, nevertheless they have an efficient system of sense organs along the lateral line, some of them reacting exclusively to sound. Eyes are well developed in all except the deep-sea dwellers; some have even specialized eyes not unlike bifocal spectacles, the upper part for vision in air, the lower for vision in water.

The most distinctive features of fishes are in regard to their spawning habits. Many individual traits are seen. Some are ocean beach spawners; others are nest builders in streams; in every instance there is perfect accord of the habit and habitat of the species. "But the facts of such adaptations for survival, the fascination of their detail and the grandeur of their mass drama, and their ages-long rhythmical repetition make ichthyology such a continuously stirring and wondrous field of exploration".

Not much attention is paid to the commercial aspect of fisheries but the authors have indicated the basic facts of fisheries management under the head "Fishes controllable by man" where we are given an account of the work on the North Pacific Halibut. The last few pages are devoted to the care and maintenance of aquaria and the choice of aquarium fish; these sections would be particularly welcome to the amateur aquarist and fish collector. A classification of fishes up to Families is appended.

The authors have presented a most enjoyable contribution to fish lore which the layman and the serious worker will find of equal interest. It is a pleasure to find such undiluted natural history which has, in these days of specialization, almost disappeared from modern publications.

N. K. PANIKKAR.

SCIENCE NOTES AND NEWS

Royal Society Medallists of the Year

The two Royal medals for the current year went to Professor Harold Jeffreys, F.R.S., for his work in geophysics and his contribution to the astronomy of the solar system, and to Professor James Gray, F.R.S., for his researches in cytology and ciliary movement, and particularly his anatomical and experimental studies of animal posture and locomotion.

The five awards made by the President and Council of the Royal Society are:

The Hughes Medal to Sir Robert Watson-Watt, F. R. S., for his work in atmospheric physics and in the development of radar;

The Darwin Medal to Professor Ronald Fisher, F. R. S., of Cambridge, whose subject is "The Effect of Blood on Evolution";

The Davy Medal to Professor E. L. Hirst, F.R.S., for his work in the determination of the structure of sugars, starches, plant gums, and especially of Vitamin C; the Rumford Medal to Professor Franz Simon, F.R.S., a refugee from Nazi Germany, who helped to produce the atomic bomb, and who won the award for his study of intense cold, having produced the lowest temperature ever recorded—nearly Absolute Nazo (*minus* 458 degrees Fahrenheit);

The Copley Medal to Professor A. V. Hill, F.R.S., for his researches on myothermal problems and on biophysical phenomena in nerves and other tissues.

Protection of Nature Conference

The Conference for the establishment of the International Union for the Protection of Nature which has been meeting at Fontainebleau (France) since September 30th, concluded its proceedings today (7 October 1948).

The meeting was called by the French Government in association with Unesco to draft and adopt the final constitution of the Union which was provisionally created last year at the Conference at Brunnen (Switzerland).

The Constitution, signed by 17 governments and 20 organizations, provides, *inter alia*, that the Union:

(*a*) shall encourage and recommend national and international action in scientific research relating to the protection of nature;

(*b*) shall promote and facilitate co-operation between governments, organizations and persons interested in the protection of nature;

(*c*) shall collect and disseminate information on that subject.

The signatory governments will also establish an extensive programme of education in this field and prepare international draft agreements and a world-wide Convention for the Protection of Nature.

The Conference also took the opportunity to hold a technical symposium to discuss nature protection problems with special reference to Europe and Africa, and has by this means set up Regional Study Groups for

Europe and Africa to crystallise the views on subjects due off discussion at the Unesco Technical Conference on Nature Protection, which the Director-General of Unesco will urge the Third Session of the General Conference to convene in the same place as, and in co-operation with, the United Nations Scientific Conference on the Conservation and Utilisation of Natural Resources, in June 1949.

The Governments which have signed the Constitution of the International Union for the Protection of Nature are: Argentina, Australia, Belgium, Brazil, Dominican Republic, Egypt, France, India, Italy, Luxembourg, Norway, Netherlands, Poland, Siam, Switzerland, Syria, Venezuela. (*By courtesy of the Principal Scientific Officer, Unesco, New Delhi.*)

Unesco Grants $7,500 to Council for Philosophy and Humanistic Studies

The United Nations Educational, Scientific and Cultural Organisation is to make a grant of $7,500 to help the International Council for Philosophy and Humanistic Studies in the early stages of its work.

The grant, Dr. Julian Huxley, Unesco's Director-General. explained, was being made in accordance with the usual practice of Unesco of supporting a promising infant.

Delegates from five international, non-governmental bodies have already met at Unesco House, Paris, to approve a provisonal Constitution and set up a Preparatory Commission for the Council.

In the words of the Constitution, the Council is, *inter alia*, to co-ordinate the dissemination of information regarding works published or begun in the field of Philosophy, Humanistic Studies and related branches of study and to encourage the setting up of international organizations in fields in which no such organizations exist.

Geomagnetic Storms

Some details of the geomagnetic storms as recorded at the Alibag Magnetic Observatory during the quarter July to September 1948 are given in the following table in which t_0 t represent the time (I.S.T.) of commencement of the disturbance and its intense phase respectively and T the duration of the intense phase expressed in hours. The ranges in the three different elements (D. H and V) of the earth's magnetic field have also been given, D, in minutes of arc, H and V in γ where $1\gamma = 10^{-5}$ gauss. The maximum k-index (K_m) recorded during the disturbance has also been given.

Date	t_0	t	T	Range			K_m	Nature of commencement
				D	H	V		
	h. m.	h. m.	hrs.	min.	γ	γ		
1948								
August 8–11	4 23	8 30	20	8·6	275	17	7	Sudden

Radiolympia 1949

Britain's 16th National Radio Exhibition (Radiolympia) is to be held at Olympia, London, from September 28 to October 8, 1949. This has just been announced by the Radio Industry Council.

Her Majesty Queen Mary has again consented to be the patron of the exhibition.

Radiolympia was last held in 1947 when it was attended by close on 400,000 people.

United Nations' Invitation to Dr. S. L. Hora

Mr. Trygve Lie, Secretary-General of the United Nations, has invited Dr. S. L. Hora, Director, Zoological Survey of India and formerly Director of Fisheries, Bengal, to prepare a paper on *Pond Culture of Warm Water Fishes* for presentation to the United Nations Scientific Conference on the Conservation and Utilization of Resources to be held in the United States of America in May or June 1949.

Jute Committee's New Secretary

Dr. J. V. Lakhani, M.Sc., A.I.I.Sc., Ph.D. (Edin.), has taken over charge on the 2nd December as Secretary, Indian Central Jute Committee, from Mr. G. C. Sen, whose term has expired.

Dr. Lakhani was the Dean of the Faculty of Science, D. J. Sind College, Karachi, and has had wide experience of administration and research. He has travelled extensively and has published several papers on academic and industrial subjects in Chemistry.

Dr. Lakhani has been taking keen interest in the problems connected with Jute Production and industry and it is expected that his rich and varied experience will prove of immense help to the Jute organisation of the Government of India.

Bombay-Kaushika Prize for 1947

The Sugar Technologists Association of India, Kanpur, have awarded the Bombay-Kaushika Prize to Mr. K. M. Gururaja Rao of Mysore Agricultural Service (Retired), Bangalore, for his publication "Sugarcane Cultivation". He was the Agricultural Officer to the Mysore Sugar Co. and organised, from scratch, sugarcane growing and supply to the factory working for 250 days in the year and crushing daily 1,500 tons. Similar work was done in Central India for the Bhopal State Sugar Industries Ltd., Bhopal. The book was reviewed in the *Current Science* of June 1947.

Change of Address

The Information Section of the Department of Scientific and Industrial Research has moved to Lower Regent Street. For the time being the remainder of Headquarters of the Department will remain at 24 Rutland Gate, London, S. W. 7.

The new address of the Information Section is:— The Department of Scientific and Industrial Research, Rex House, Regent Street, London, S. W. 1.

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SIR C. V. RAMAN AND CRYSTAL PHYSICS*

OPTICAL theory and the physics of crystals are linked together almost inseparably in the history of their development. It is not surprising, therefore, that his love of optics has led Sir C. V. Raman to take an ever-increasing interest in crystal physics, as will be evident from the titles of the papers communicated by him to the Academy during the past decade or two. Many aspects of the subject have received his attention at some time or another. More recently, also, he has considered the fundamental problems of crystal physics from a standpoint which, while it is essentially novel, has proved highly successful in explaining the facts of observation. In these circumstances, it has appeared desirable to include in the present Symposium on Crystal Physics which commemorates his Sixtieth Birthday, a classified list of the papers on the subject which have emerged from his laboratories during the last thirty years. It is of particular interest to trace the development of his ideas and to indicate the fundamental character of the contributions made by him and his school. This will be done in the present survey.

Some of the most beautiful illustrations of optical principles are to be found in the phenomena of crystal optics. Haidinger's and Quetelet's rings in crystalline plates, the iridescence of twinned crystals of potassium chlorate, the optical effects observed with amethystine quartz, the diffraction of light by the laminar boundaries in mica and the haloes observed in the Christiansen experiment with crystal powders are amongst the subjects of this kind investigated during the earliest years of Raman's professoriate by his pupils. The phenomena of conical refraction exhibited by biaxial crystals have also had a special fascination for him. Amongst the discoveries made in this field may be mentioned that of the formation of sharply focussed optical images by plane plates of biaxial crystals. That naphthalene crystals have an extremely large angle of conical refraction and exhibit the effects arising therefrom in a very striking way is another significant contribution. Many studies have also been published of the beautiful phenomena exhibited by the nacreous layer in molluscan shells and the manner in which they are influenced by the size, shape and relative orientation of the platelets of aragonite appearing in its stratifications.

2. THE SCATTERING OF LIGHT IN CRYSTALS

In the latter part of 1921, Raman commenced his studies on the diffusion of light in transparent media. These were systematically pursued over a period of years until finally they led to the discovery of the effect

* From the Sir C. V. Raman Sixtieth Birthday Commemoration Volume, *Proc. Ind. Acad. Sci.*, Nov. 1948, Bangalore.

known by his name. The work of this epoch was of significance for crystal physics in several ways. The first major contribution which emerged at an early stage was the discovery of the phenomenon of the *thermal diffusion of light in crystals*. Raman was led to recognize its existence by the fact that the clearest crystals available to him, *viz.*, a polished sphere of quartz and a large transparent block of ice, both exhibited a blue opalescence when traversed by a concentrated beam of sunlight and that the intensities observed were of the right order of magnitude, both relatively and absolutely. Ice, which has a high compressibility, showed the phenomenon more conspicuously than quartz, in spite of the higher refractive index of the latter. The inference suggested by these facts, *viz.*, that the scattering had its origin in the fluctuations of optical density in the crystal due to the thermal agitation was confirmed by heating a quartz block. The intensity of the opalescence was then found to increase, as was to be expected.

Following these early observations, the work with crystals was laid aside and studies with gases and liquids were energetically pursued, as they offered a larger variety of promising material for quantitative work. In February 1928, Raman switched over from sunlight to the monochromatic radiations provided by the mercury arc for his studies on light scattering. When his pocket spectroscope revealed clearly the appearance of radiations of altered frequency in the light scattered by liquids, he instantly realised the importance of looking for a similar phenomenon in the light scattered by crystals as well as by amorphous solids. Observations with a large block of crystalline ice showed sharp displaced lines in approximately the same positions as those observed with distilled water. This fact and its theoretical significance are clearly brought out in the paper announcing the discovery of the effect. The magnitude of the frequency shifts observed with ice showed that the phenomenon was of a different nature from the hermal diffusion of light in crystals discovered in 1921, and was to be accounted for on the same basis as the corresponding effect observed with water, *viz.*, an exchange of energy between the incident light quanta and the vibrations of the structural units of the substance.

3. Birefringence and Pleochroism in Crystals

Apart from the discovery of the Raman effect, the studies on the scattering of light in gases and liquids carried on during the years 1921 to 1927 opened up several other pathways of research. They threw a vivid light on the nature of the liquid state, showing clearly that it is far from being a random distribution in space of the molecules composing it. This led Raman to seek a confirmation of his ideas by undertaking with the aid of his collaborators a series of systematic studies on the X-ray diffraction haloes of liquids and glasses. The results obtained in these studies were found to be explicable on the same basis as the facts observed earlier in light-scattering. Of special significance to crystal physics were the deter-

minations of the optical anisotropy of the molecules or ions made possible by measurements of the intensity and depolarisation of light-scattering in fluids. A correlation became evident between the optical anisotropy of molecules in fluids and the birefringence exhibited by the same substances in the crystalline state. This indicated that the birefringence of crystals is determined principally by the optical anisotropy of the molecules or ions and by the manner in which they are orientated with respect to the crystal axes. Thus, from the known optical anisotropy and the observed features of the birefringence, it becomes possible to draw useful conclusions regarding the structure of the crystal. Indications of this kind were found to be particularly useful in cases where the optical anisotropy and the birefringence are both large, *e.g.*, organic crystals of the aromatic class.

The extensive data obtained regarding optical anisotropy also enabled some general conclusions to be drawn regarding the relation between this property and the chemical constitution of the molecule. It emerged that a large optical anisotropy is accompanied by the presence of absorption in the near ultra-violet or visible region of the spectrum. Further, in such cases, the crystals of the substance exhibit a marked pleochroism in which the axis of maximum absorption coincides with that of the largest optical polarisability, though there are some exceptions to this rule.

4. Magnetic Anisotropy of Crystals

Many papers on magnetism and magneto-optics figure in the published output of Raman's school. The early studies on light-scattering, remarkably enough, gave an impetus to work in this field. Magnetic birefringence in liquids owes its origin to the fact that while the magnetic field tends to orientate the molecules, their optical anisotropy results in double refraction. Thus, simultaneous studies on magnetic double refraction and on light-scattering in liquids enable the magnetic anisotropy of the molecules or ions to be evaluated and connected with the magnetic anisotropy of the solid crystal of the same substance. The known magnetic behaviour of the crystalline nitrates and carbonates was successfully explained by Raman and Krishnan in this way. The large magnetic anisotropy of the benzene ring deduced by them in the same fashion proved to be a fundamental discovery, since it led to the recognition of the still larger anisotropy of other aromatic molecules and opened the way to the interpretation of the magnetic behaviour of crystals of those substances. Indeed, magnetic studies were shown to be a powerful aid to crystal structure analysis by the early work of Bhagavantam with naphthalene and anthracene. So impressed was Raman by the importance of the method that he initiated studies on magnetic birefringence in many liquids in which it had not been previously observed. This work led to the discovery of the weak negative birefringence exhibited by water, the aliphatic hydrocarbons and other liquids. Crystals of substances exhibiting such negative magnetic birefringence show a relation

between their magnetic and optical behaviour quite different from that of crystals of substances, *e.g.*, the aromatic series, which show a positive magnetic birefringence in the liquid state.

5. Raman Effect Studies

Raman's discovery of 1928 opened up a vast new field of activity which was naturally taken up by his collaborators with enthusiasm, and many publications dealing with different aspects of the subject emerged from his laboratory. The effect exhibited by crystals was in the foreground of this activity from the beginning in view of its evident importance for an understanding of the theory of solids; indeed, during the last ten years, work with gases and liquids has been completely laid aside in favour of crystals which present both a challenge and an incentive to investigators in the field. They are a challenge since the difficulties of obtaining satisfactory material and of eliminating spurious effects due to parasitic illumination and instrumental defects are great. They are an incentive, since the sharpness of the Raman lines observed with crystals encourages employment of the most powerful instruments capable of revealing the maximum of detail and yielding data with the precision characteristic of spectroscopy. The major aim of the work in recent years has been that of elucidating the physical problems of the solid state, the substances chosen and the studies undertaken being both determined by this aim. Amongst the topics investigated are the following: the influence of temperature on the sharpness, position and intensity of the lines; the changes in the spectra accompanying thermal transitions in the crystal; the change from the solid to the liquid state; the identification of the modes of vibration active in light-scattering; the influence of crystal symmetry and structure on the spectra, and so forth. We cannot here describe either the techniques employed or the results obtained in these researches. It is necessary, however, to mention an important group of investigations designed to elucidate the fundamental problem of the nature of the vibration spectrum of a crystal. Taking for instance, the case of diamond, its Raman spectrum as ordinarily recorded is a single extremely sharp line with a frequency shift of 1332 $cm.^{-1}$ Obviously, this cannot represent the complete vibration spectrum and there should be other frequencies in it. The task of establishing their existence has been successfully accomplished by the present writer and the results are of very great interest. The results show in a perfectly unambiguous way that the vibration spectrum of diamond consists of a whole series of sharply defined discrete frequencies, of which only the highest is represented by the frequency shift of 1332 $cm.^{-1}$ The remaining frequencies do not appear in the first-order Raman spectrum ordinarily recorded. But with adequate exposures they appear as overtones and combinations in the so-called second-order Raman spectrum. The latter has also been successfully recorded with numerous crystals besides diamond.

6. The Thermal Scattering of Light

We return to the phenomenon discovered by Raman in 1921, namely the thermal diffusion of light in crystals. The thermal agitation which gives rise to it may be identified with stationary elastic vibrations of various modes and frequencies determined by the elastic constants and by the size and shape of the crystal. The diffusion itself would arise from the modulation of the optical wave-motion by the elastic vibrations and should therefore exhibit frequency shifts, while its strength would be determined by the photoelastic properties of the crystal. It would evidently not be easy to determine the distribution of intensity in the resulting spectrum unless, following L. Brillouin, we regard the crystal as of infinite extension. Whether this is always permissible is a question.

The frequency shifts to be expected theoretically are small and therefore not easily determined; lack of perfect monochromatism in the incident radiation and any Tyndall scattering present give rise to serious experimental difficulties. The subject is, nevertheless, of great interest and many studies have been published. Particular success has been achieved in the case of diamond which gives large frequency shifts not requiring interferometric aid for their observation. A perfect elimination of the Tyndall scattering is also possible by the use of the resonance radiation of mercury and a mercury vapour filter. An experimental result of great importance which has been established with this technique is that the elastic vibrations in a crystal are wholly incapable of giving rise to an observable diffusion of light, unless their "wave-lengths" are such as to give a regular Brillouin reflection. The behaviour of the elastic vibrations in the crystal is thus in complete contrast with that of the modes of vibration with discrete frequencies which readily record themselves in the second-order Raman spectrum even when they do not appear in the first order.

7. The Vibration Spectra of Crystals

A fundamental question in the theory of the solid state is the nature of the vibration spectrum of a crystal. The new approach to the solution of this problem made by Raman is based on the idea that since we are concerned with the vibrations of a mechanical system, we have necessarily to consider its "normal modes". Further, the approach to the problem of finding these modes is necessarily different for the "elastic" vibrations in a continuum, and the "atomic" vibrations in a discrete structure. In the former case the vibrational modes and frequencies are determined by the external boundary conditions, while in the latter case, the time-periodic movements in the units of the structure are analogous to the vibrations of a polyatomic molecule and hence the external boundary conditions are wholly irrelevant. Following up this idea in a straightforward way, Raman derived his fundamental proposition that the structure of a crystal having

p atoms in each of the cells of its structure has $(24p-3)$ normal modes of vibration, and the same number of discrete frequencies of vibration unless this is reduced by reason of symmetry of the crystal and consequent degeneracy of the modes. This is a result of far-reaching importance which explains in a completely quantitative fashion the experimental results mentioned in the preceding two sections. In particular, the experimental fact that the 'elastic vibrations' of a crystal are wholly inactive in light-scattering (except in the case of a Brillouin reflection), while the structural vibrations are active in the second-order if they are not active in the first-order is a clear indication that they are different in their physical nature. The recognition of such a difference is, in fact, the starting point of the new theoretical approach.

8. The Structure and Properties of Diamond

Diamond is a substance of extraordinary interest to the physicist engaged in the study of crystals, since it exhibits the characteristic properties of the solid state in an exceptional degree. For this reason the investigation of the physical behaviour of diamond has of recent years formed one of the principal activities of Raman's laboratory and many papers have been published describing the results.

The properties of diamond may be broadly divided into two groups. The first group comprises those that do not exhibit significant variations as between different specimens of diamond. This group includes density, hardness, elasticity, thermal expansion, specific heat, thermal conductivity, refractivity, dispersion, photoelasticity, dielectric constant, magnetic susceptibility, Faraday effect, Raman effect, and infra-red absorption of the second and higher orders. The second group of properties are those which exhibit variations, often of a most striking character, as between different diamonds. Amongst them may be listed infra-red absorption of the first order, absorption spectra in the visible and ultra-violet regions, fluorescence excited by visible and ultra-violet light and by X-rays, phosphorescence, photoconductivity, optical birefringence, intensity and sharpness of the Laue and Bragg X-ray reflections, and dynamic X-ray reflections. If the variations in the properties listed above had been unrelated to each other, the study of the diamond would indeed have been a very perplexing subject. Happily, this is not so, as has been shown by Raman and his collaborators by studies covering all the properties listed above with an extensive collection of material. The results present such striking correlations between the variations of the different properties as to leave no room for doubt that differences are systematic and arise from fundamental differences in crystal structure. This inference receives direct observational support from studies on the crystal morphology of diamond. The situation may be summed up broadly by the statement that the electronic structure of diamond may possess either tetrahedral or octahedral symmetry. Assuming each atom

of carbon to possess only tetrahedral symmetry, geometric consideration indicate that there must be two sub-species (positive and negative, respectively) of the tetrahedral type and two sub-species of the octahedral type. The recognition of the existence of these four species of the diamond structure, appearing separately or together in any actual specimen of diamond enables the varied behaviours actually met with to be satisfactorily described and interpreted.

9. Luminescence and Absorption Spectra

The luminescence of diamond, a long-known but neglected phenomenon, has been studied with great thoroughness by Raman and his collaborators with results of exceptional interest. Two distinct types of luminescence based on different electronic transitions are observed, and the same electronic transitions can also appear in absorption. They may be coupled with vibrational transitions in the crystal lattice and as the result, the principal emission or absorption in each case appears accompanied by subsidiary radiations of less and greater frequency respectively. The emission and absorption spectra exhibit mirror-image symmetry with respect to each other about the electronic frequency. The lattice frequencies deduced from the spectra agree with those given by the new crystal dynamics, which was in fact first developed to explain the effects observed in the luminescence spectrum of diamond.

The coupling of electronic with vibrational transitions so clearly manifested in the case of diamond is a general feature in the luminescence spectra of crystals. As a consequence, Raman effect studies are of great assistance in interpreting such spectra. As an illustration, one may cite the case of the fluorescence and absorption of the uranyl salts, as also the cases of alumina and of topaz investigated by the present writer. The lattice frequencies of magnesium oxide calculated on the basis of theory fit very well with those deduced from its luminescence spectra resulting from the presence of a trace of chromic oxide as impurity.

10. Infra-Red Absorption Spectra

All diamonds without exception exhibit an infra-red absorption spectrum of the second order, while the diamonds of the tetrahedral class exhibit also a first order absorption. These spectra have been thoroughly investigated and are explicable in all their details on the basis of the new lattice dynamics. Particularly interesting is the fact that the two weakest second-order Raman lines (2176 $cm.^{-1}$ and 2015 $cm.^{-1}$) are represented in the second-order infra-red absorption by its two most conspicuous peaks, as is to be theoretically expected. A feature which manifests itself conspicuously in the first order infra-red absorption by diamond is that all the nine fundamental modes of vibration of the lattice are active, though in different degrees, and not merely the so-called principal oscillation having the highest frequency.

The absorption curves exhibit distinct peaks corresponding to the different modes, but their resolution is far from perfect. These features are explicable as due to the coupling of the different modes with each other due to anharmonicity. Such coupling would necessarily manifest itself even more strongly in the case of strongly infra-red active crystals and offers a basis for an explanation of the features exhibited by their absorption spectra.

11. Thermo-Optic Properties of Crystals

Studies of the effect of temperature on the optical properties of diamond have pointed the way to the development of a successful quantitative theory of the thermo-optic behaviour of crystals. The refractive index of diamond increases instead of diminishing with rise of temperature, this increase becoming more rapid as we approach the violet end of the spectrum. In consequence, the dispersion of diamond is enhanced by rise of temperature even more rapidly than its refractive index. The sharply defined electronic absorption lines in the visible and ultra-violet region exhibited by diamond at low temperatures are observed to drift towards lower frequencies when the temperature is raised. It may therefore be reasonably assumed that the characteristic frequency in the extreme ultra-violet principally responsible for the dispersion also shifts downwards with rise of temperature. Such a shift would result in an increase of dispersion and refraction which would only be partially be set off by the diminution caused by the thermal expansion. Not only does this idea work successfully in the case of diamond, but it is found to be remarkably successful also in explaining the facts observed with numerous other crystals, both those which are isotropic, *e.g.*, the alkali halides and those which are birefringent, *viz.*, quartz, calcite and aragonite. The basis of the theory, namely the diminution of the characteristic frequencies in the remote ultra-violet with temperature, also finds direct observational support.

12. Photoelastic Properties of Crystals

One of the earliest attempts to develop a quantitative theory of the photoelastic behaviour of crystals was that made at Raman's suggestion in 1927 by Kedareswar Banerji. The subject has acquired considerable importance in recent years by reason of its relationship to other phenomena, *viz.*, the optical effects arising from mechanical oscillations in a crystal and the thermal diffusion of light. The theory of the diffraction of light in ultrasonic fields originally put forward by Raman and Nath to explain the effects observed in liquids, applies *mutatis mutandis* to the case of a crystal when the relevant piezo-optic constants are introduced in the formulæ. The recent determination of the piezo-optic constants of diamond was, in fact, made with a view to work out the consequences of Brillouin's theory of the thermal scattering of light in it. Measurements with other crystals will no doubt prove of great value in this field of research.

13. Magneto-Optic Behaviour of Crystals

One of the many remarkable properties of diamond is the feebleness of the Faraday effect observed with it when considered in relation to its high dispersive power. The rotation of the plane of polarisation of light produced by a magnetic field is only one-fourth of that to be expected on the basis of the well-known Becquerel formula. The measurements which revealed this fact were made possible by the plates of diamond free from birefringence included in Raman's collection. The explanation for the low value is evidently to be found in the covalent character of the bonding of the atoms of carbon in the crystal with each other. The case of diamond thus clearly indicates that measurement of the "magneto-optic anomaly" exhibited by a crystal offers a method of ascertaining the nature of the electronic states in its atoms or ions. Studies with other crystals have since been pursued with this aim in view.

14. Elastic Properties of Crystals

Methods based on the use of piezo-electrically excited oscillations have opened out new possibilities for the accurate determination of the elastic constants of crystals. The recent work of Bhagavantam and his collaborators at Waltair may be specially mentioned in this connection. The problem naturally arises of seeking to connect these experimentally observed constants with the known crystal structure and if possible to derive them theoretically on the basis of that structure. The first step in any such attempt is evidently the evaluation of the interatomic forces arising from the displacements of the atoms from their positions of equilibrium. One way of finding these forces is to connect them with the frequencies of atomic vibration made accessible to observation by the Raman effect and from these frequencies as actually observed to evaluate the forces. A rigorous method of accomplishing this has been worked out in the case of various crystals. Difficulties arise in the next step, namely that of evaluating the elastic constants from the interatomic forces, but we shall not discuss them here.

15. The Thermal Properties of Crystals

The evaluation of the specific heat of a crystal requires a knowledge of its vibration spectrum. The proposition that this spectrum consists of $(24p-3)$ discrete frequencies places the theory of specific heats on a very simple and intelligible basis. Further, when these frequencies are accessible to direct spectroscopic observation, a comparison between the actual and calculated specific heats becomes possible. It may be remarked that the three excluded degrees of freedom represent the spectrum of elastic vibrations in the crystal. These appear at the very lowest end of the frequency range. Hence in most cases it is a sufficient approximation to regard them as fully excited at the temperature of observation and make the necessary addition to the specific

heat; a more exact calculation may, however, be necessary if p be small and if the temperature is very low. Calculations of the specific heat made in this manner for crystals for which the necessary spectroscopic data are available, *e.g.*, diamond, show a satisfactory agreement with the facts.

Another property of a crystal which is intimately related to its vibration spectrum is its thermal expansion. Data regarding the thermal expansion coefficient of crystals are rather meagre. For example, no data were available for diamond above the room temperature. The present writer has developed a new precision method of measuring the coefficient of thermal expansion of crystals and applied it to the case of diamond which, as is well known, has a very small dilatation. Attempts to evaluate the thermal expansion of diamond and of other crystals theoretically on the basis of the spectroscopic data as in the case of their specific heats have given very encouraging results.

16. X-Ray Studies

The striking developments in X-ray physics which followed in the wake of Laue's great discovery of 1912 were already accomplished facts when Raman commenced his professoriate. Hence, neither X-ray spectroscopy nor crystal structure analysis was ever adopted by him as a part of his regular research programme. Nevertheless, these subjects have interested him greatly, as will be evident from the numerous X-ray studies published from time to time from his laboratory.

In April 1940, Raman and Nilakantan published in an article in *Current Science* under the title "A new X-ray effect", some strongly exposed Laue photographs obtained with an octahedral cleavage plate of diamond and the X-radiation from a copper target. These photographs showed some remarkable features which they explained as arising from dynamic reflections of the incident X-radiation by the (111) planes of the crystal. They gave reasons for believing that the crystal planes giving these reflections were set in vibration with the same frequency as that observed in the Raman spectrum of diamond and that the excitation was quantum-mechanical as in the case of the Raman effect. The reality of the effect is indisputable and on the basis of the explanation indicated, it is clearly of fundamental importance. Raman and Nilakantan subsequently published further experimental results which confirmed the correctness of the explanation given by them. We shall not here enter further into the subject except to remark that the explanation of this X-ray effect stands in the closest relation to the problem of the nature of the vibration spectrum of a crystal. The same question also enters fundamentally into the theory of the diffraction of X-rays by crystals and of the influence of temperature on the same.

R. S. Krishnan.

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